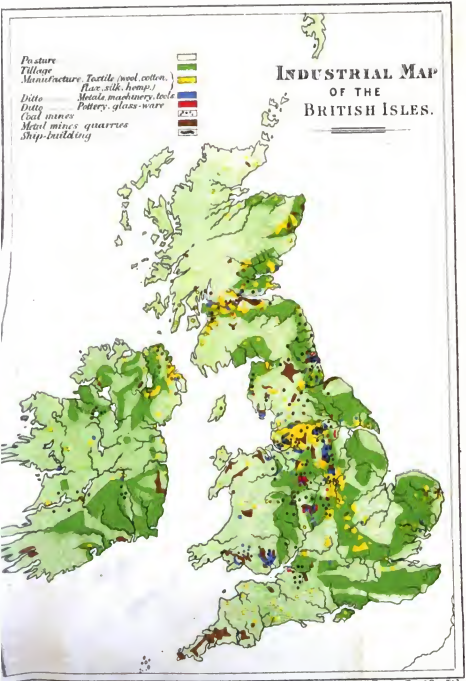

Yeats' Technical History of Commerce.

Vincent Brooks, Day & Son, Lith.

TECHNICAL, INDUSTRIAL, AND TRADE EDUCATION.

THE TECHNICAL

HISTORY OF COMMERCE;

OR,

SKILLED LABOUR APPLIED TO PRODUCTION.

BY JOHN YEATS, LL.D., ETC.

ASSISTED BY SEVERAL SCIENTIFIC GENTLEMEN.

"Ingenuas didicisse fideliter artes,
Emollit mores nec sinit esse feros."—OVID.

LONDON:
VIRTUE & CO., 26, IVY LANE,
PATERNOSTER ROW.
1872.

To

DR. LYON PLAYFAIR, M.P., F.R.S., &c.,

WHOSE EARNEST EFFORTS ON BEHALF OF

TECHNICAL INSTRUCTION

HAVE TENDED TO DIGNIFY INDUSTRY AND TO FRUCTIFY CAPITAL,

TO LIFT LABOUR FROM THE DUST,

AND TO BRING

THE MEANS OF LIVING

MORE INTO HARMONY WITH

THE TRUE ENDS AND AIMS OF LIFE,

THIS VOLUME

Is gratefully inscribed

BY

JOHN YEATS, LL.D.

A

KEY TO CONTENTS.

PROLOGUE.

"I SAW wild animals grazing in large savannahs, and carnivorous beasts, such as lions and tigers, occasionally disturbing and destroying them. I saw naked savages feeding upon wild fruits, or devouring shell-fish, or fighting with clubs for the remains of a whale which had been thrown upon the shore. I observed that they had no habitations, that they concealed themselves in caves, or under the shelter of palm-trees; and that the only delicious food which Nature seemed to have given to them was the date and the cocoa-nut, and these were in very small quantities, and the object of contention. I saw that some few of these wretched human beings who inhabited the wide waste before my eyes had weapons pointed with flint or fish-bone, which they made use of for destroying birds, quadrupeds, or fishes, that they fed upon raw; but their greatest delicacy appeared to be a maggot or worm, which they sought for with great perseverance in the buds of the palm. . . . .

"A country opened upon my view which appeared partly wild and partly cultivated; there were fewer woods and morasses than in the scene which I had just before viewed. I beheld men who were covered with the skins of animals, and who were driving cattle to enclosed pastures. I saw others who were reaping and collecting corn, others who were making it into bread. I saw cottages furnished with many of the conveniences of life, and a people in that state of pastoral and agricultural improvement which has been imagined by the poets as belonging to the golden age. The attendant said, 'Look at these groups of men who are escaped from a state of infancy; they owe their improvement to a few superior minds still among them. That aged man whom you see with a crowd around him taught them to build cottages; from that other they learnt to domesticate cattle; from others to collect and sow corn and seeds of fruit. And these arts will never be lost; another generation will see them more perfect. The houses in a century more will be larger and more convenient, the flocks of cattle more numerous, the corn-fields more extensive; the morasses will be drained; the number of fruit-trees increased.' . . . .

"In the scene which followed that of the agricultural or pastoral people, I saw a great extent of cultivated plains, large cities on the sea-shore, palaces, forums, and temples ornamenting them ; men associated in groups, mounted on horses, and performing military exercises ; galleys, moved by oars, on the ocean ; roads intersecting the country, covered with travellers, and containing carriages moved by men or horses. . . . . 'See,' said the genius, 'the few men to whom the foundations of these improvements were owing have had divine honours paid to their memory. But look at the instruments belonging to this generation, and you will find that they are only of brass. Observe the men who are talking to crowds around them, and others who are apparently amusing listening groups by a kind of song or recitation. These are the earliest bards and orators ; *but all their signs of thought are oral, for written language does not yet exist.*'

"The next scene which appeared was one of varied business and imagery. There was a man, who bore in his hands the same instruments as our modern smiths, presenting a vase which appeared to be made of iron, amidst the acclamations of an assembled multitude engaged in triumphal procession before the altars dignified by the name of Apollo, at Delphi ; and in the same place were men who carried rolls of papyrus in their hands, and wrote upon them with reeds containing ink made from the soot of wood mixed with a solution of glue. 'See,' cried the genius, 'an immense change produced in the condition of society by the *two arts of which you here trace the origin ; the one, that of rendering iron malleable*, which is owing to a single individual, an obscure Greek ; *the other, that of making thought permanent in written characters*, an art which has gradually arisen from the hieroglyphics which you see on yonder pyramids.' . . . .

"I beheld the bronze instruments which had belonged to the former state of society thrown away ; malleable iron converted into hard steel, and this steel applied to a thousand purposes of civilised life. I saw bands of men who made use of it for defensive armour and for offensive weapons ; by-and-by these iron-clad men, in small numbers, subduing thousands of savages, and establishing amongst them their own arts and institutions. I saw a few men on the eastern shores of Europe resisting with the same materials the united forces of Asia ; next a chosen band die in defence of their country, destroyed by an army a thousand times as numerous ; and very soon this same army, in its turn, caused to disappear, and destroyed or driven from the shores of Europe by the brethren of that band of martyred patriots. I saw bodies of these men traversing the sea, founding colonies, building cities, and, wherever they established themselves, carrying with them their peculiar arts. Towns and temples arose, containing schools, and libraries filled with the rolls of

papyrus. The same steel, such a tremendous instrument of power in the hands of the warrior, was applied, by the genius of the artist, to strike forms even more perfect than those of life out of the rude marble; and the walls of the palaces and temples were covered with pictures, in which historical events were portrayed with the truth of nature and the poetry of mind. The voice now awakened my attention by adding, 'You have now before you that state of society which is an object of admiration to the youth of modern times, and the recollections of which, and the precepts founded on these recollections, constitute an important part of your education. Your maxims of war and policy, your taste in letters and arts, are derived from models left by that people or by their immediate imitators.' . . . .

"I looked again, and witnessed an entire change in the aspect of this Roman world. The people of conquerors and heroes were no longer visible; the cities were filled with an idle and luxurious population; those farms which had been cultivated by warriors, who left the plough to take the command of armies, were now in the hands of slaves, and the militia of free men were supplanted by bands of mercenaries, who sold the empire to the highest bidder. I saw immense masses of warriors collecting in the North and East . . . . ruin, desolation, and darkness were before me, and I closed my eyes to avoid the melancholy scene. 'See,' said the genius, 'the melancholy termination of a power believed by its founders invincible, and to be eternal. But you will find, though the glory and the greatness belonging to its military genius have passed away, yet those belonging to the arts and institutions by which it adorned and dignified life will arise in another state of society.' . . . .

"I opened my eyes once more, and saw Italy recovering from her desolation; towns arising, with governments almost upon the model of ancient Athens and Rome, and these different small states rivals in arts and arms. I beheld the remains of libraries, which had been preserved in monasteries and churches, by a holy influence which even the Goth and Vandal respected, again opened to the people; regal Rome rising from her ashes, the fragments of statues found amidst the ruins of her palaces and imperial villas becoming the models for the regeneration of art. I saw magnificent temples raised in this city, become the metropolis of a new and Christian world, and ornamented with the most brilliant masterpieces of the arts of design. I found a Tuscan city, as it were, contending with Rome for pre-eminence in the productions of genius, and the spirit awakened in Italy spreading its influence from the South to the North. 'Now,' said the genius, 'society has taken its modern and permanent aspect. Consider for a moment its relations to letters and to arms, as contrasted with those of the ancient world.' I recog-

nised that, in lieu of the rolls of papyrus, libraries were now filled with books. 'Behold,' said the genius, 'the printing-press. *By the invention of Faust the productions of genius are, as it were, made imperishable, capable of indefinite multiplication, and rendered an unalienable heritage of the human mind. By this art, apparently so humble, the progress of society is secured,* and man is spared the humiliation of witnessing again scenes like those which followed the destruction of the Roman empire. Now look to the warriors of modern times; you see the spear, the javelin, the shield, and cuirass are changed for the musket and the light artillery. The German monk who discovered gunpowder did not meanly affect the destinies of mankind. Wars are becoming less bloody by becoming less personal; mere brutal strength is rendered of little avail; all the resources of civilisation are required to maintain and move a large army; wealth, ingenuity, and perseverance become the principal elements of success. Civilised man is rendered, in consequence, infinitely superior to the savage, and gunpowder gives permanence to his triumph. . . . .

"'The practical results of the progress of physics, chemistry, and mechanics are of the most marvellous kind, and to make them all distinct would require a comparison of ancient and modern states. Ships that were moved by human labour in the ancient world are transported by the winds; and a piece of steel touched by the magnet points to the mariner his unerring course from the Old to the New World; and by the exertions of one man of genius, aided by the resources of chemistry, a power which by the old philosophers could hardly be imagined, has been generated, and applied to almost all the machinery of active life. *The steam-engine* performs not only the labour of horses but of man, by combinations which appear almost possessed of intelligence. Wagons are moved by it, constructions made, vessels caused to perform voyages in opposition to wind and tide, and a power placed in human hands which seems almost unlimited. . . .

"'In the common history of the world, as compiled by authors in general, almost all the great changes of nations are confounded with changes in their dynasties; and events are usually referred either to sovereigns, chiefs, heroes, or their armies, which do, in fact, originate from entirely different causes, either of an intellectual or a moral nature. Governments depend far more than is generally supposed upon the opinion of the people, and the spirit of the age and nation. It sometimes happens that a gigantic mind possesses supreme power, and rises superior to the age in which he is born. Such was Alfred in England and Peter in Russia; but such instances are very rare, and in general it is neither amongst sovereigns nor the higher classes of society that the great improvers or benefactors of mankind are to be

found. The works of the most illustrious names were little valued at the times when they were produced, and their authors were either despised or neglected; and great indeed must have been the pure and abstract pleasure resulting from the exertion of intellectual superiority and the discovery of truth, and the bestowing benefits and blessing upon society, which induced men to sacrifice all their common enjoyments and all their privileges as citizens to these exertions. . . . . I have said that in the progress of society all great and real improvements are perpetuated. The same corn which four thousand years ago was raised from an improved grass, by an inventor worshipped for two thousand years in the ancient world under the name of Ceres, still forms the principal food of mankind; and the potato, perhaps the greatest benefit that the Old has derived from the New World, is spreading over Europe, and will continue to nourish an extensive population when the name of the race by whom it was first cultivated in South America is forgotten.'"

(Extracted, by the kind permission of John Murray, Esq., from Sir Humphry Davy's "Consolations in Travel."—Dialogue I., Fourth Edition, 1838.)

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From DR. LYON PLAYFAIR'S *Address at the Social Science Congress*, 1870.

"The first direct compulsory law relating to education in this kingdom that I have met with in my studies was passed by James IV. of Scotland, in 1494. He ordained that all sons of freeholders and barons should go to school under penalty, and that their eldest sons, who were to have the estates, should, after their preliminary examination, attend three years at a school of law, in order that they might administer, discreetly and wisely, justices' justice to the poor folk of the realm. It is a pity that this compulsory law does not still exist for eldest sons! You see in it the idea ***that education should be adapted to the work of life.*** This main idea of fitting a man for his work was vigorously supported by our old reformers. John Knox held firmly by it, especially in his scheme for secondary education, which, unfortunately for Scotland, was never adopted, though his plan for primary education was. In the former he announced that no boys should leave school till they had devoted a proper time to 'that study which they intend chiefly to pursue for the profit of the commonwealth.' This is the old conception of the object of education, and ***reappears at the present day under the modern garb of 'Technical Education.'*** All the reformers urged its necessity, especially Luther and Melancthon. Most European states have held fast to the idea, with more or less of development, but it has vanished utterly from our English schools."

PREFACE.

THIS sketch of Technical History, or Skilled Labour applied to Production, will, I hope, be found useful, in assisting "*to direct the subject-matter of education more to the occupations of the people*," an object which the Committee of Council, in 1839, determined to promote.

But, notwithstanding the exertions of that body, of the Society for the Diffusion of Useful Knowledge, of the Society of Arts, of Publishers, and of Scientific Men, whose spirit-stirring appeals are echoed by the Daily Press, there is not yet, to my knowledge, any *Manual* showing the development and progress of the Industrial Arts, though such a work seems indispensable to Capitalists and to all who are concerned in the administration of Capital.

In attempting to remedy the deficiency in part, let me premise that the following treatise is founded on popular continental works; it is not, however, a translation or an abridgment, but an original production, designed to aid such of my young fellow-countrymen as may wish to profit by the trade collections and the art museums of the metropolis. In it, irrelevant or debatable matter has been studiously avoided, yet every effort in my power has

been made to bring into prominence those agencies through which past industrial progress has been effected, as well as to indicate the methods by which further advance may be anticipated.

As affording some preparation for this task, the fact of my having spent more than two years of early manhood in the industrial institutions at Hofwyl, near Berne, may, perhaps, be mentioned. The experiments carried on there by the Fellenberg family during nearly half a century attracted attention on both sides of the Atlantic.*

Opportunities have also occurred to me for visiting Piedmont, and for inspecting the libraries and museums of Central and Southern Italy. To a short stay at the Mining Academy of Freyberg, in Saxony, I am indebted for several particulars relating to mineral processes, and to the customs of the Middle Ages.

For the very kind assistance rendered me of late by many gentlemen, at home and abroad, I return most grateful acknowledgments.

J. Y.

Peckham, June, 1871.

* For information on Hofwyl, in English, see "Third Report from the Select Committee on the Education of the Lower Orders"—ordered by the House of Commons to be printed, 3-8 June, 1818 (by Lord Brougham), *Edinburgh Review*, December, 1818.

AN INDUSTRIAL CHART.

MATERIALS.

A knowledge of the raw materials that enter into the different departments of business can only be obtained from the Natural History Sciences, sometimes called the *Sciences of Observation*:—

GEOLOGY, treating of—

- Modes of Occurrence of Metallic Ores, Mineral Fuel, and Building Materials.
- Agricultural Soils.

MINERALOGY—

- Constituents of Mineral Substances, Metals, Earths, &c.

GEOGRAPHY—

- Distribution of Animals and Vegetables.
- Climate as Determining the Introduction of Useful Plants and Animals.

ECONOMIC BOTANY—

- Food and Textile Products.
- Timber and Fuel.
- Oils, Gums, and Resins.

ECONOMIC ZOOLOGY—

- Food and Textile Products.
- Furs and Leather.
- Bone and Ivory.
- Oils.

They form the basis of

"THE NATURAL HISTORY OF THE RAW MATERIALS OF COMMERCE."

LABOUR.

Mere manual labour is little better than raw material, and sinking in value as an element of production. Mental labour is rising, and the chief requisite in the following divisions of industry, which are practical applications, for the most part, of the *Experimental and Transformational Sciences*:—

MECHANICAL, comprising—

- Building.
- Clothing.
- Engineering.
- Manufacturing.
- Mining.
- Printing, &c.

CHEMICAL—

- Assaying.
- Baking.
- Bleaching.
- Brewing.
- Dyeing.
- Smelting, &c.

PHYSIOLOGICAL—

- Agriculture.
- Cattle-rearing.
- Gardening.

MENTAL—

- Education.
- Government.
- Language.
- Medicine.
- Natural Philosophy.

A sketch of the rise and progress of these, excepting the last group, is given in

"THE TECHNICAL HISTORY OF COMMERCE; or, Skilled Labour applied to Production."

COMMERCE.

The lower animals construct, and carry, and lay up; but only human beings *exchange* and add value to produce, by conveying it from places in which it is superabundant to others in which scarcity prevails. The requirements of commerce involve a knowledge, among other things, of—

- Account-keeping.
- Banking.
- Commercial Geography.
- " History.
- " Law.
- Correspondence, the Art of.
- Credit, the Functions of.
- Exchange, at Home and Abroad.
- Foreign Languages.
- Indemnity and Insurance, Principles of.
- Materials (Raw).
- Manufactures.
- Means of Transport.
- Money, of all Kinds.
- Political Economy.
- Statistics of Trade.
- Usages and Risks of War.
- Wealth, as Convertible or Inconvertible.

These enter into the curriculum of all the Trade Schools of Germany and the Low Countries, and a contribution to the course will be found in

"THE INDUSTRIAL AND POLITICAL HISTORY OF COMMERCE."

THE

Technical History of Commerce;

OR,

SKILLED LABOUR, APPLIED TO PRODUCTION.

INTRODUCTORY.

In a beautiful story* which was probably founded on fact, Heinrich Zschokke tells how a Swiss family of wandering tinkers or pedlars became in the second generation braziers, girdlers, and military accoutrement makers, and in the third were at the head of a brass and iron foundry, casting batteries for arsenals and bells for cathedrals.

They established, moreover, a polytechnic school, not more for the study and practice of particular arts required in their own business than for the exposition and inculcation of those principles of integrity and of liberality on which all business of an honourable character must everywhere be conducted.

That story the venerable author gave me to translate into English many years since; and I now propose trying to show, without romance or fiction, how the human family, as a whole, have advanced from a condition of helpless

* "Labour Stands on Golden Feet."

dependence on the wild fruits of the seasons, or on the spoils of the ocean, to that of intelligent agriculturists, miners, manufacturers, and merchants.

Such a survey can hardly fail to promote a study of the arts, and, incidentally, of the sciences, as well as to perpetuate the memory of some of the world's benefactors.

The plan of the work will lead us at once to the primitive haunts of industry. The first workmen wrought where materials were most easy of access. As wants increased, crafts multiplied, and centres of production appeared in particular localities, often becoming permanently characteristic of them: thus, the "garb of old Gaul" survives in our Highland tartans, and modern France still loves gay colours.

It will be desirable in this introductory chapter to illustrate the meaning attached to terms employed; to point out the relation between Art and Science; to exemplify the development of the latter, and, by quoting the writings of eminent men on all matters about which a difference of opinion may well exist,—such as the mode or rate of human progress,—the standard by which the value of an invention or discovery should be tested,—the importance of a general study of physical science, &c., to show that reference has been made to acknowledged authorities.

Technical history is a history of all the arts that minister to man's requirements. This technical history of commerce is limited to the industrial arts and handicrafts.

The word "art" may be traced a long way back, and it usually has the meaning of fitness and symmetry. Skill is inseparably connected with it.* Art lightens labour and crowns it, but art is not to be found in every kind of labour. The hauling of a rope, the turning of a crank, or the driving of cattle cannot be included among the arts, yet the successful performance of even such labour demands knowledge, the result of experience.

* "*Summa ars est artem celare*" (The highest art is to conceal art).

We may speak of technical knowledge, technical skill, and technical ability. Each of these occurs in the well-known experiment from M. Rondelet, "*Sur l'Art de Bâtir*," introduced to us by Mr. Babbage, in his "Economy of Manufactures." The task was the shifting of blocks of squared granite, each weighing 1,080lbs., from the place where they were found to that of their destination. To move such a mass along the floor of a roughly-chiselled quarry requires a force equal to 758lbs. An ignorant man must employ and pay several assistants, or he can never move such a block an inch. But to draw the same block over a floor of planks will require a force of only 652lbs. The expense of one assistant, therefore, might be dispensed with. Placed on a platform of wood, and drawn along the same floor, a draught of 600lbs. would be sufficient. By soaping the two surfaces of the wood, the requisite force would be reduced to 182lbs. Placed on rollers three inches in diameter, a force equal to 34lbs. would be sufficient. Substituting a wooden for a stone floor, the requisite force is 28lbs. On a wooden platform, with the same rollers, 22lbs. only would be required. And, now, by the invention and use of locomotives and tramways, a traction or draught of between three and four pounds is found to be sufficient. Thus the amount of force necessary to move a body weighing 1,080lbs. is reduced about 200 times; moreover, the condition of the workman is improved from that of a mere operative to that of the driver of a steam-engine, his emoluments, no doubt, rising in proportion.

Let us take another example from an American source. "If a savage learn how to swim, he can fasten a dozen pounds' weight to his back, and transport it across a narrow river, or other body of water of moderate width. If he will invent an axe, or other instrument, by which to cut down a tree, he can use the tree for a float, and one of its limbs for a paddle, and can thus transport many times the former weight many times the former distance. Hollowing out his log, he will

increase what may be called its tonnage, or, rather, its poundage; and, by sharpening its ends, it will cleave the water both more easily and more swiftly. Fastening several trees together, he makes a raft, and thus increases the buoyant power of his embryo water-craft. Turning up the ends of small poles, or using knees of timber instead of straight pieces, and grooving them together, or filling up the interstices between them in some other way, so as to make them watertight, he brings his rude raft literally into ship shape. Improving upon hull below and rigging above, he makes a proud merchantman, to be wafted by the winds from continent to continent. But even this does not content the adventurous naval architect. He frames iron arms for his ship, and for oars fixes iron wheels, capable of swift revolution, and stronger than the strongest sea."

In this technical sketch we see the log of a savage transformed, by slow stages of advance, into the mail-steamer of the Atlantic, and a barbarian become a scientific mariner; but we must not forget a multitude of circumstances that influenced the sequence of events, such as the requirements of traders, the kind of cargoes available, the power to victual ships for long voyages, the police of the seas, the state of geographical knowledge, the spirit of maritime adventure, the invention of the compass, the application of steam to locomotion, and the extended use of iron, consequent on its greater abundance and cheapness, &c. All these causes, conditions, and coincidences come within the province of the historian, whose duty it is not merely to narrate facts, but to show the connection subsisting between them—to demonstrate the principles on which human actions proceed and by which they are controlled.

Having glanced at applications of the term "technical" to knowledge, skill, and ability, and also to history, let us see how it might be *misapplied;* and then proceed to the subjects of art and science, taken conjointly and separately.

Whatever can be reduced to rule and measure seems

properly to partake of a technical character. A bricklayer's labourer is a handy man, whose business it is to fix scaffolding, make mortar, or temper cement; yet, inasmuch as he works mostly by "rule of thumb," or by no rule at all, his particular knowledge is not accounted technical, while that of the master bricklayer is so considered. The latter works by measurements chiefly, and nearly all that he does can be checked by level, plumb, and square. But were the bricklayer to lose these instruments, or be required to construct them afresh, he would have to call in the aid of another and a higher worker, the man of science, who, strangely as it may sound to the ear, would be able to tell whether a new foot-rule were too long or too short, or whether a pint-pot held good measure, if he could compare them, as to their dimensions, with the pendulum of a clock beating seconds of time in the Observatory at Greenwich.

"Art fits and disposes,"—how then, are science and art so closely related? "Science for the most part designs and contrives, while art executes. They appear, therefore, to be parent and child; yet art also invents, and makes discoveries which science explains. In some cases, these inventions and discoveries are extremely advantageous to an individual, until science detects and reveals the secret, rendering that which was previously known only to the most gifted and experienced equally clear and plain to every beginner in life, and thus making that which had been a monopoly of one the common property of all mankind."*

Science and art are, nevertheless, sadly estranged in industrial life, and have been so from the beginning. The want of union between the two, the failure in perfect communication and harmony between them, has, more than any one cause, and probably more than all other causes combined, occasioned the slow pace of industrial progress.

* "Induktion und Deduktion."—Liebig, 1854.

Mr. Horace Mann, Secretary to the Board of Education for Massachusetts, alluding to this circumstance in his twelfth report, forcibly remarks:—"Mankind had made great advances in astronomy, in geometry, and other mathematical sciences, in the writing of history, in oratory, and in poetry, in painting and in sculpture, and in those kinds of architecture which may be called regal or religious, centuries before the great mechanical discoveries and inventions which now bless the world were brought to light; and the question has often forced itself upon reflecting minds why there was this '*preposterousness*,' this inversion of what would appear to be the natural order of progress? Why was it, for instance, that men should have learned the courses of the stars and the revolutions of the planets before they found out how to make a good wagon-wheel? Why was it that they built the Parthenon and the Coliseum before they knew how to construct a comfortable, healthful dwelling-house? Why did they build the Roman aqueducts before they framed a saw-mill? Or why did they achieve the noblest models in eloquence, in poetry, and in the drama before they invented movable types? I think we have arrived at a point where we can unriddle this enigma. The labour of the world has been performed by ignorant men, by classes doomed to ignorance from sire to son; by the bondmen and the bondwomen of the Jews, by the helots of Sparta, by the captives who passed under the Roman yoke, and by the villeins, and serfs, and slaves of more modern times."

In support of Mr. Mann's views, we may take into consideration that at the time when learning was at its maximum in Athens, Western Europe was inhabited by half-savage tribes, whose only dress was the skins of wild beasts. We should remember too that even in the thirteenth century Rome was the centre of commerce for Christian slaves, while at Lyons, and in the sea-coast towns of the Baltic and the German Ocean, large slave-markets were held.

As classes are no longer *doomed* to ignorance, at least in this country, and as villeinage and bondage have disappeared, let us hope that the estrangement between art and science may become a thing of the past.

To illustrate the development of science so far as it affects the signification and the application of words, and to show the difficulty of judging rightly concerning industrial or scientific progress without comprehensive views of the subject, the following paragraphs from Baron Liebig's "Entwicklung der Ideen in der Naturwissenschaft," 1866, are submitted.

"The Greeks knew that the air in a bladder resists pressure, and that a glass turned downwards in water does not of itself become full of water; air was regarded as a space-filling, resisting substance, as an element, and, next to fire—that is, to the smoke which rises—as the lightest element. Till the beginning of the sixteenth century, men considered air as transformable into water; in the middle of that century they knew that air is *not* transformable to water, the discovery having been made that air contains water in the form of vapour. In 1630 it was observed that air is a heavy, *i.e.*, a ponderable substance; in 1643 that it is one which presses on all bodies on the surface of the earth with its whole weight; in 1647 that the invisible particles of air press on each other, and are elastic—thus that the lower strata of air are denser than the upper—in 1660 that artificial kinds of air, elastic, like the common atmosphere, can be artificially produced; in 1727 that there are also such kinds of air in plants, in animal tissue, stones, and calcareous minerals—not products, but educts—many combustible, others fire-extinguishing; in 1774 that among them is a kind of air in which combustible materials burn more briskly than in common air; in 1775 that the atmosphere is composed of a mixture of two kinds of air, of which one supports combustion, the other not, besides containing variable quantities of steam; at the end of the eighteenth

century, that it also contained carbonic acid; in the nineteenth century, ammonia and nitric acid; and, lastly, that spores of fungi of all sorts are floating in it."

Our present position with regard to the conception of air has been acquired by the work of hundreds of the most acute men, during a space of more than two thousand years, and by the continual enlargement, separation, and limitation of the first idea. Therein consists the difference between the conception of bodies and of their actions in former times and at the present day.

What modern Europe still possesses of ancient Greek civilisation was preserved during the Middle Ages by the Eastern Roman Empire and the Arabs. But this period did more than merely transmit to a later age the relics of a bygone knowledge. In proof of this we have but to observe what had been done in the domains of art and science at the commencement of the Modern Period. At the close of the fifteenth century, in mathematical science, algebra and trigonometry had been extended, and the decimal system of notation had been introduced; a closer acquaintance with astronomy had led to improvements in the calendar; chemistry had made considerable progress, and the foundation had been laid for revolutionising the theory and practice of medicine. In the arts, improvements had been effected in the processes of mining, smelting, dyeing, weaving, tanning, and glass-making, in the construction of roads, bridges, and buildings, and in the old corn-mills and weaving-looms. Amongst the inventions that had been made prior to this period might be named those of paper, telescopes, fire-arms, watches, table-forks, horse-shoes, bells, chimneys and flues, wire-drawing machines, the manufacture of steel, engraving upon wood, copper, and glass, glass mirrors backed with an amalgam of mercury and tin, wind-mills, saw-mills, &c.

This seems a suitable opportunity for an examination of the terms "Invention" and "Discovery." By an invention

we shall here understand a new application of existing knowledge; by a discovery, some addition to knowledge already possessed. Necessity, it is commonly said, is the "mother of invention;" it has been said, too, that "every invention is the child of its time." These aphorisms indicate in a concise form the characteristics of an invention. Inventions are the outcome of a felt want. They spring from the inadequacy of existing means to meet growing urgencies; so that the notable inventions of any particular age or condition of society bear upon them the impress of the circumstances which gave them birth. The same typical character does not appertain to discoveries. They are not, as inventions, the issue of a struggle with an urgency which it is imperative to satisfy. Let us compare two concrete examples. The recognition of the property of polarity possessed by the magnet would be called a discovery; it was the perception of a before unknown power, a positive addition to the knowledge previously possessed. The mariner's compass, a practical application of this property of polarity to the purposes of navigation, would be called an invention; it was the application of existing knowledge to a new purpose. The former, it is clear, might have been made—we do not say it was so made—by a scientific investigator, not operating under the guidance of a pressing want which must be satisfied; and the knowledge might have remained barren of any practical application. But the latter was lighted upon when men's minds were impelled by the necessities called into being, through a rapid extension of maritime traffic, to seek for a surer means of guidance at sea than already existed.

From this contrast between invention and discovery, we pass to a consideration of the standards by which the value of an invention or discovery is tested. The capital but not necessarily connected criteria are two, viz., (1) its efficacy in meeting the requirements of existing wants, and the consequent social changes brought about by it; and

(2) the amount of ingenuity, study, and labour expended by the inventor before his idea was worked out to its practical realisation. Judged of by these standards, the value of an invention may be called respectively its *utilitarian*, or *extrinsic*, and its *intrinsic* value. Of these in their order.

To society the former is the more important criterion of the value of an invention or discovery. To the interests of mankind at large it matters little whether any invention or discovery has cost its author the study and labour of a year or of half a lifetime. If it satisfy existing requirements, it is valued; if otherwise, neglected. One fallacy must be guarded against in judging of the value of an invention or discovery. The social conditions of the period to which it belongs must be taken into account. It would be palpably unfair to judge of an invention of ten or twenty centuries ago by the standard of to-day. When arts are rude and appliances few, the invention of the simplest new tool, the introduction of some new agency, an improvement in some simple process of manufacture, may, when judged of relatively, be of equal importance with inventions and improvements of far higher pretensions, and even absolute value, in a more advanced state of society. He who lightened human toil by the utilisation of the strength of an animal produced a change which, all circumstances considered, is fairly comparable with that which followed the introduction of steam-power into manufacturing operations. The inventor of the hammer—who, perhaps, copied the close analogy of the fist clenched for a blow—and the inventor of the mighty steam-hammer, may be relatively benefactors of equal importance, each to his own age. So, too, the first rude mattock for breaking the soil and the first fish-bone perforated at one end to serve as a needle may fairly rank with the steam-plough and the sewing-machine.

Of the second, or intrinsic value of an invention, little needs be said in a work of which the main object is

to exhibit the social changes which have resulted from progress made in the arts, and in intellectual pursuits. The most notable inventions and discoveries have been those most characterised by the ingenuity and persevering labour expended upon them. Nor is this all; perfect familiarity with the subject-matter, assiduous study of its principles, and a peculiar bent of mind have been exhibited by every distinguished inventor and discoverer. It may safely be said that the perfection of the steam-engine could only have been the work of a Watt, the discovery of the principle of gravitation, of a Newton; that is to say, of men with their peculiar knowledge, their bent of mind, their indefatigable labour; and, in the former, his practical acquaintance with every detail of machinery and high mechanical skill.

Inventions and discoveries are often spoken of as though they were the result of accident. What has been stated above is a sufficient disproof of this. And even in those cases where discovery seems to have been, to say the least, powerfully aided by accident, a closer inquiry will show that there existed some causes which, absent, the discovery would have remained unmade. When a new phenomenon presents itself, if the observer fails to appreciate it, through want of the proper faculty of scientific research, or of sufficient familiarity with cognate phenomena, or of that turn of mind which is ever ready to seize the new and the strange, the opportunity is for the time lost, and the discovery is deferred till a fitting observer appears. "For example, how many thousands of times will it have happened, that two different metals placed in a vessel of water have by their contact engendered a galvanic current, and decomposed the water. The rising air-bubbles must have been perceived, but there was wanting the comprehension of the phenomenon, and before it could be comprehended other preliminary discoveries had to be made.

"The discoverer of gunpowder will not have set himself

to work to make the discovery as Davy, for instance, did to produce a safety-lamp, as a mechanician at the present day plans his new machine on paper; but the repeated experiment marks the inventive talent of the first maker of gunpowder—another would have had enough with the first fright, and would not have exposed himself a second time to the presumably diabolical effects of that mysterious mixture." *

To sum up this matter in a few words, both invention and discovery depend upon a knowledge of the laws of nature, resulting from industrious and enlightened research. *They are the finest ears of corn selected from the fairest fields, and will be found not by the wayside, but where the husbandry is best—where nothing is neglected to render the soil fertile and the seed superior.*

Having now separately considered the terms Art, Science, Invention, and Discovery, there remains but one more—"Technology," which is here mentioned that it may not be confounded with technical history; and also to show the connection between this volume and its predecessor, "The Natural History of the Raw Materials of Commerce."

Technical History refers to the ARTS exclusively, while Technology is "the sum or complement of all the SCIENCES that either are or may be made applicable to the industrial labours or utilitarian necessities of man." Such sciences may be variously classified, but we consider them under two heads mainly—observational, and experimental or transformational.

The former volume described raw materials and their useful properties, so far as these are presented to us *spontaneously* by Nature. The present volume has as its business incidentally to tell how *latent* powers and unsuspected properties have been revealed to us by interference with Nature. The former was ancillary to a study of the sciences of observation; this is intended to illustrate observation aided

* "Bildungsgang und Bildungsmittel der Menschheit."

by experiment or by labour, and applied to the utilisation of natural objects, forces, and phenomena. *Practices*, not processes, form our subject.

The difference between the observational and the experimental sciences is chiefly one of degree, the latter involving a greater expenditure of time and labour, but with results proportionately more precise; and the two divisions of science can always be pursued simultaneously. "The industrialist must study one side of all physical science to consider what gifts Nature offers him with her liberal hand. He must study another side of all physical science to discover how to turn these gifts to account, *e.g.*, geology finds a bed of coal, but chemistry tests its value in the market, cooks or cokes it, distils from it gas, naphtha, the aniline colours, &c.; mineralogy selects iron-ores for us, chemistry converts them into steel, and mechanics converts that into bars, blades, or watch-springs; descriptive botany plucks a wild currant, physiological botany changes it into a sweet grape, chemistry ferments it into wine, and transforms that into ether; descriptive zoology lays its hand on a caterpillar, physical zoology nurses it into a strong silkworm, chemistry bleaches and dyes the silk which it spins, and mechanics weaves it into ribbon and velvet."

Need aught now be added in favour of the study of science? Even astronomy, usually regarded as the most abstruse and least applicable to ordinary purposes, has led to discoveries of a very practical nature In evidence of this, let us again have recourse to the writings of the late Professor George Wilson, of Edinburgh. He says, with singular force and beauty:

"Daily the conviction deepens among those who have studied the matter, that, with few exceptions, all the physical powers which man wields as movers or transformers of matter are modifications of sun force. It was bestowed upon antediluvian plants, and they locked it up for a season in the woody tissue which it enabled them to weave, and after-

wards time changed that into coal; and the steam-engine, which we complacently call ours, and claim patents for, burns that coal into lever-force and steam-hammer power, and is, in truth, a sun-engine. And the plants of our own day receive as liberally from the sun, and condense his force into the charcoal which we extract from them, and expand in smelting metallic ores. With the smelted metals we make voltaic batteries, and magnets, and telegraph wires, and call the modified sun-force electricity and magnetism, and say it is ours, and ask if we may not do what we like with our own. And, again, the plants which we cultivate, concentrate sun-force in grass, hay, oats, wheat, and other grains and fibres which seem only suitable to feed cattle and beasts of burden with. . . . Let me remind you that, as force cannot be annihilated any more than matter, but can only be changed in its mode of manifestation, so it appears beyond doubt that the force generated by the sun, and conveyed by his rays in the guise of heat, light, and chemical power, to the earth, is not extinguished there, but only changes its form. It apparently disappears when it falls upon plants, which never grow without it; but we cannot doubt that it is working in a new shape in their organs and tissues, and reappears in the heat and light which they give out when they are burned. This heat, which is sun-heat at second-hand, we again seem to lose when we use plants as fuel in our boiler-furnaces; but it has only disguised itself, without loss of power, in the elasticity of the steam, and will again seem lost when it is translated into the momentum of the heavy piston, and the whirling power of a million of wheels. The second-hand heat of the sun appears equally lost when vegetable fuel is expended in reducing metals; but oxidise these metals in a galvanic battery, and it will reappear as chemical force, as electricity, as magnetism, as heat the most intense, and, in the electro-carbon light, will return almost to the condition of sunshine again.

"The second-hand plant-heat appears equally lost when vegetables are eaten by animals, but, in reality, re-appears in their so-called animal heat, and in the chemical, electrical, and other forces which act upon and within them. It re-appears, also, I do not doubt, in their vegetable life, and changes into what we call vital force. Do not, however, misunderstand me, as going beyond physical force. Life, remember, is not mind. The immaterial spirit, the immortal soul, is far above the sun. We know him, and we know ourselves, but he knows neither himself nor us.

"Astronomy thus stands much nearer industrialism, in all its departments, than perhaps any of us fully realise. I cannot wonder that men, even practical men, were once astrologers. A dim sense of obligation to the heavenly bodies for something more than starlight was obscurely felt perhaps by all, and rested, as the stable foundation-stone of a worthless building, at the bottom of the fantastic erection which formed the astrology of the Middle Ages. And still more intelligible is sun-worship. Only by a fallen and a rebel angel could such be uttered as, 'I add thy name, O Sun, to tell thee how I hate thy beams!' The worst of men would recall that God 'maketh his sun to rise on the evil and on the good;' and across the chasm of centuries, I own to a sympathy with the pagan who worshipped as a God the bountiful sun." *

* From the *Technologist*, August 1, 1854, edited by P. W. Simmons, Esq., and continued, as the *Journal of Applied Science*, under the same able management.

PART I.

PRE-HISTORIC AND ANCIENT INDUSTRIAL ART; OR, THE ORIGIN OF THE USEFUL ARTS AND THEIR EARLIEST HISTORY.

CHAPTER I.

PRE-HISTORIC INDUSTRIAL ART; OR, THE ARTS AS KNOWN TO PRIMEVAL MAN.

ARCHÆOLOGY.

ARCHÆOLOGY (αρχαιος, "ancient," λόγος, "discourse"), or the study of ancient things, was formerly restricted to the research into Egyptian, Greek, and Roman antiquities. It has now a much wider and nobler range, embracing all such knowledge of the early history of mankind as lies beyond the direct testimony of written history, and is derived, by the process of induction, from the remains and traces of the earlier conditions of human existence preserved to us, upon and under the surface of the earth. It includes or is closely interwoven with several other departments of human knowledge, among which may be reckoned the scientific inquiry into the variety, mutual connection, and origin of languages (*Philology*); the diversities and present geographical diffusion of man, and the causes on which these are dependent (*Ethnology*); and the origin of the art of writing (*Palæography*). Investigation has been extended in all these directions, and several chapters, long deemed irrecoverably lost, have been added to the volume of human history.

We have had revealed to us facts supposed to be buried in oblivion, or seen only dimly through the mists of fable and superstition. Reasons have been found for referring the existence of man upon the globe to a much more remote period of time than had been indicated by the records of written history. Undoubted traces of human beings and their constructive arts, in a very primitive state, have been found in connection with geological formations, which had once been considered not only as pre-historic, but as pre-human. A careful study of these unwritten records shows, in the most diverse regions of the world, a remarkable identity of detail, and has led to a broad division of human history into the three stages of the *Stone*, the *Bronze*, and the *Iron* periods, founded upon the nature of the materials known to and possessed by man for the construction of his weapons and tools, whereby the whole circumstances of his life and action were circumscribed and determined. These "periods," it is to be remembered, are, so far as regards humanity as a whole, states of society, or *stages of progress*, rather than periods of time. While, for instance, under favourable circumstances for advancement, the tribes around the Mediterranean and Indian seas had emerged from the Stone Period thousands of years ago, this stage still existed in the isles of the Pacific when they were first visited by Europeans; and it has not ceased at the present day among some of the Indians of the Rocky Mountains, where the "ancient arrowmaker" still shapes his flakes of flint, obsidian, and jade into spear and arrow-heads, precisely similar to those used in Britain more than 2,000 years since.

It is when we refer to the first historic nations that a consideration of these successive periods of human development impresses us so powerfully with the antiquity of the race. These nations had already attained to a knowledge of metallurgy, and to the vantage-ground which resulted therefrom at the earliest dawn of their history. Beyond that horizon of the known, an unknown period stretches away,

during which the stage of progress was attained with which their written history begins.

SECTION I.—THE STONE PERIOD.

In all parts of the world in which researches have been made, there have been found underlying the hoary civilisations of India and Egypt and the ancient glories of Greece and Rome, as well as the barren moors of Scotland, the lakes of Switzerland, and the peat deposits of Scandinavia, evidences of a period in the history of those countries when their inhabitants as yet knew none of the useful metals, and possessed no other materials for implements of war or the chase than wood, stone, and the horns and bones of the animals on which they fed. From the fact that the more important and more lasting of these weapons were fashioned of flint or other stones, whose hardness enabled them to receive a cutting edge, this stage of human history has been called the Stone Period. Among the earliest specimens of the constructive industry of the period are the rudely-fashioned flints, found in large numbers in gravel-pits near Amiens and Abbeville, in the north of France, and more sparingly in existing or ancient river-beds in this country; those found in many caverns in England, France, and other countries, in connection with bones of man and extinct mammalia, shells, &c., and forming a hard *breccia* or conglomerate, often covered with a thick deposit of stalagmite; those occurring at the bottom of lakes in Switzerland, Ireland, and Scotland, and pointing to a time when a considerable population dwelt in huts reared upon stakes above the surface of these lakes; and those found in the heaps of shells and other refuse of food occurring along the coasts of the Baltic, where they are known by the name of *Kjökken-mödding*. With the lapse of time, improvements were made in these weapons, for among the later productions of the Stone Period which have come down to us, there are many objects of great elegance and delicacy of finish, which we

cannot but admire when we think of the scanty appliances possessed by the primitive manufacturer, and the disadvantages under which he pursued his labours.

Palæolithic and Neolithic Ages.—Sir John Lubbock, in his recent work on this subject, makes two great divisions of the European Stone Period, viz.:—First, the Palæolithic or Old Stone Age, the implements of which are rude and unpolished, without any known traces of metal; and during which the climatic conditions of Europe, as evidenced by the remains of the contemporary animals which have become extinct, must have been very different from those which now obtain under the same latitudes. The period of time during which this stage of history existed in Europe must have been correspondingly remote. Second, the Neolithic or New Stone Age, exhibiting a considerable advance in civilisation, an acquaintance with the ornamental metals, silver and gold, or the latter at least, and enjoying climatic conditions similar to those now existing. This stage of civilisation, as we have remarked, has scarcely passed away in some parts of the world, yet the principal European nations must have emerged from it nearly 2,000 years before the Christian era, and it must have terminated, as we have seen, at a still earlier period in the countries stretching from Egypt to the far East.

Among the remains of the constructive art of the Stone Period, in addition to the arrow and spear heads, are adzes or chisels, technically called "celts," ponderous stone hammers, and other cutting, sawing, chipping, or striking implements, some of which were probably bound to a stout wooden handle by a thong of skin or bark. We find querns or hand-mills of all kinds, from two stones, with flattened sides, for mere rubbing together, to the more finished contrivance, in which the top stone was pierced by a central funnel-shaped aperture, by which it could revolve on a pivot fixed in the centre of the lower stone, and through which the grain or seeds to be ground could be poured in. Skewers, pins, combs, and

hooks, made of the bones of fish and quadrupeds; domestic utensils made of shells; ornaments of parrot-coal, jet, and shell; and urns or culinary vessels of sun-baked clay, plain or ornamental, with parallel "herring-bone" markings, also occur.

Man a Hunter or a Fisher.—In the condition of society indicated by the Stone Period, man may be said to have been a hunter or a fisher, dwelling either in caverns, in huts on the margins of rivers, lakes, and the sea-shore; or in bowl-like depressions in the earth, occurring in the woods and on the hill-sides, which he covered with fallen trees. In such localities we find the débris of his food, consisting, on the sea-shore, of fish-bones, and immense heaps of shells of the cockle, whelk, and other mollusks; elsewhere of the bones of quadrupeds slain in the chase, most of them split up in order to extract the marrow; and on the sites of the lake dwellings, the shells of nuts and other vegetable products of the locality. The skins of the animals slain in the chase served doubtless as his clothing, and at a late epoch in the same period there even appear traces of the art of the weaver. During this age, also, the seas were navigated and islands visited by the aid of the earliest canoes, of which several have been discovered at a great depth under the present surface in the alluvial tracts bordering the Firths of Forth and Clyde in Scotland. These were formed from a single trunk of oak, and seem to have been constructed by means of the flint celt, assisted by the agency of fire. Kindling a fire around the root of some monarch of the forest, the primeval shipbuilder tended it from day to day, assiduously breaking off the charred portions with his flint hammer, so as constantly to expose a fresh surface to the flame. After the tree had fallen, it was, by a similar process, stripped of its branches, and reduced to a convenient length; then a line of fire kindled all along its trunk, aided by the blows of the celt, gradually hollowed out the centre to a depth sufficient to accommodate the

adventurous mariner, who, embarked in this primitive keel, obtained more plentiful supplies for his family, or trafficked with neighbouring shores. That some traffic was at this time carried on between distant tribes is shown by the fact that the spear and arrow heads, and other weapons found in so many localities, are made of stone which does not occur *in situ* within hundreds of miles; other objects also occasionally appear which must have been brought from great distances.*

The agency of fire alluded to above has been at all times a powerful force in the hands of man. No record exists of any race of men unacquainted with the use of fire, although the myths of Greece suggest a time when this heavenly gift was first conveyed to man.

The use of fire, indeed, constitutes one of the great distinctions by which man is differentiated from the lower animals. All other creatures fear and avoid fire; in none is there discernible the slightest tendency to produce, control, or use it, either for their own comfort or for any other purpose. To primeval man, an obvious use of fire would be to frighten away beasts of prey by its brightness, and, perhaps, to obtain protection from noxious insects by its smoke. It was probably soon discovered that meat dried and smoked by the fire withstood decomposition for a much longer time than that which was raw, and in this process

* Intercourse between races but little in advance of the cave-dwellers in Europe is proved by certain discoveries made among the ancient dwellings on Lake Moosseedorf, near Berne. Sir C. Lyell writes: "Although the flint here employed must have come from a distance—probably from the South of France—the chippings of the material are in such profusion as to imply that there was a manufactory of implements on this spot. Here, also, as in several other settlements, hatchets and wedges have been observed of a kind of jade, said not to occur in Switzerland or in the adjoining parts of Europe, and which some mineralogists would fain derive from the East; amber, also, which it is supposed was imported from the shores of the Baltic."—"Antiquity of Man," p. 20.

may be traced the commencement of the art of cooking. The discovery would also be made that vessels of burnt clay were much more durable than those baked in the sun; and to the accidental fusion of metallic ores on the spot where a fire had been kindled, man was no doubt indebted for his first ideas of metallurgy, and a new material for his tools and weapons, for which the clumsier implements of the Stone Period were soon abandoned.

SECTION II.—THE BRONZE PERIOD.

The Age of Stone was succeeded in most of the historical countries by the Bronze Period. Experience or accident, as we have just seen, taught the fortunate dwellers in some region of the earth the existence of a crude or mixed metal, which could be hammered or melted into weapons of greater power and durability than those of bone, wood, and stone. This metal was chiefly copper, which is found in many parts of the world nearly pure, and fit for working. Gold and silver seem to have been known in most countries from a very early period, but their scarcity and beauty, as well as softness, have caused them to be rarely used in construction. It is, indeed, most probable that gold was the first metal known to all people in early stages of civilisation, for, besides its attractive appearance, it is almost the only metal found in a native state upon or near the surface, and consequently obtainable without much labour, and without smelting. In some countries weapons and utensils of pure copper have been found, but this metal is also in itself too soft to be usefully applied to such purposes, and from a very remote period we find that it was hardened and adapted to use by the addition of tin, thus forming the alloy called "bronze." This compound is not only harder than its component metals, and more susceptible of receiving a cutting edge, but it is also more fusible and malleable; it is, therefore, well adapted for the manufacture of instruments either for domestic or warlike purposes. The ancient

bronze weapons consist usually of eighty-seven and a half per cent. of copper and twelve and a half of tin, or seven of the former to one of the latter. Nearly all the bronze celts, spear and arrow heads, swords, hatchets, statues, and coins which have been discovered show a similar composition, and that the best for producing the required degree of hardness and toughness. This identity in the composition of ancient bronze points to a common source whence the knowledge of working the metals was derived; and a similar conclusion is suggested by the fact that the localities where tin was to be found were very few, being confined chiefly to the Island of Banca, in the Indian Archipelago, and the mines of Cornwall, in Britain. It is therefore probable that the working of this metal and the art of alloying it were discovered in the East, and brought to the West by the Phœnicians, who, we know, carried tin or its ores from Cornwall to Tyre and Sidon. The bronzes of Assyria and of Egypt were probably made with the tin raised in Britain, and imported into Egypt by the Phœnicians more than a thousand years before the Christian era. It was very likely through the agency of this remarkable people that the Stone Period came to an end on the shores of the Mediterranean and the Baltic, as it has expired in our own day in Polynesia and North America, through the iron weapons and tools introduced by European traders. It is to be remembered that wherever mention is made of "brass" in ancient records, as is very frequently the case in the Old Testament, the poems of Homer, &c., the substance in question is not modern brass, an alloy of copper with zinc—then an unknown metal—but brónze, the alloy of copper and tin. There can be little doubt that the tin of Cornwall entered into the composition of the spears and shields of the Grecian warriors, as well as of the brazen chariots of the kings of Syria, and the pillars, capitals, and lavers of molten brass cast for Solomon's Temple by the Tyrian Hiram, "a worker in brass, filled with wisdom, and understanding, and cunning

to work all works in brass." In the Pentateuch, the actual use of iron is scarcely mentioned, all the utensils of the Tabernacle, for example, including pots, pans, shovels, basins, flesh-hooks, rings, mirrors, and fire-grates, being of bronze. In Tubal-cain, "the father of all such as work in brass and iron," we seem to have a reference to the first introduction of metallurgy, many generations later than the father of the race.

The oldest bronzes are of rude construction, and scarcely superior to the stone weapons which served as their models; they appear to have been hammered into form, rather than cast. It was not long, however, before the art of casting found its way into the most remote corners of Europe, where stone moulds for casting bronze implements have been discovered in abundance, accompanied, in some cases, by the newly-cast weapons themselves. According to Cæsar, the massive rings of copper and bronze which were worn by the Britons at the period of the Roman invasion, were obtained from foreign merchants, though the tin and iron found were native.

The commencement of the Bronze Period introduces us to the first traces of a wide-spread commerce, in which the adventurous mariners of Phœnicia distributed the produce of the smelting-furnaces of Tyre and Sidon among the nations of the West, and thus were instrumental in raising them to a higher stage of civilisation. The "metallic transition" was, of course, a gradual one. The powerful chief might procure his bronze sword or spear-head, while the poor dependant was still employing his stone axe, and flint arrows. Stone, apparently, never went quite out of use, till iron appeared, and, by its plenty and cheapness, superseded both stone and bronze; in fact, the most elaborate and highly-finished stone implements belong really to the Bronze Age. When the bronze was not procurable in sufficient quantities to make all the weapons, it could, at least, be used for constructive tools, by means of which better flint

weapons would be produced, and the stone or bone implements carved and adorned. In the same way, iron has not abruptly superseded stone weapons in the South Sea Isles. The islander prefers iron when he can obtain it, but has often to be content with the older materials.

Relics of the Bronze Period have been found in all European countries. An examination of the earliest Egyptian sculptures has also shown that these were executed, not with iron, but with bronze chisels. In America, the Mexicans and Peruvians had reached the Bronze stage when invaded by the Spaniards, whom they opposed with weapons of bronze, although they retained for common purposes many of the implements of the Stone Age. The introduction of iron by the Spaniards, brought to a close the Bronze Period in these countries. In many other districts the inhabitants—who never of themselves advanced as far as the Bronze stage, but were still in the pristine Stone Period when visited by Europeans—passed, through intercourse with them, directly into the Iron Period, without the intervention of the middle stage. This has been the case in Australia, where the still unreached natives represent the Stone stage of human progress, for their hatchets and tomahawks resemble some of the flint instruments found in Northern and Central Europe. In Europe, the middle period was already passed when Rome was acquiring her ascendency, and for European nations generally the authentic part of Roman history may be classed as falling under

SECTION III.—THE IRON PERIOD.

Pastoral and Agricultural Stages of Society—Permanent Habitations.

Iron, unlike copper, does not occur anywhere in a pure workable condition; and, though one of the most widely diffused of the elements, it exists almost always in the disguised form of earthy or stone-like ores. The art of extracting the metal from these ores indicates a more

advanced state of knowledge than was necessary for the working or casting of native copper, hence we find that the knowledge and use of iron became common at a considerably later period. The mention of iron in connection with Tubal-Cain has already been noticed. According to ancient classic accounts, the discovery of this metal was accidentally made through the burning of forests on Mount Ida, whereby the stones were melted, and the iron flowing in streams disclosed to the astonished view of the inhabitants, a new material. Whether this account be historical or mythical, it is no doubt substantially true, and the discovery to which it refers is one of the most important that have influenced human history. When we think how much we are indebted to iron tools and appliances for the preparation of so many of the things which we eat, or wear, or see around us, we realise what must be the helplessness of a people who know nothing of this metal, and we recognise the fitness of the name, "Iron Period," bestowed upon the third of the ages of humanity. With the knowledge of iron, civilisation proper may be said to begin, and, following its influence, we soon leave the pre-historic night, and enter upon the dawn of the historic ages. It is with the record of man's doings under the Iron Period that this work is to be occupied.

The choice of means for obtaining a livelihood was in few cases free to primitive man; soil, climate, and natural productions everywhere shaped it for him. He obtained his food from the fish and mollusks of the sea, from the beasts of the field, or from the fruits of the earth. In the section treating of the Stone Period, we saw that the lowest condition of human society was that in which man was mainly a hunter or a fisher. Going on to the higher conditions, we may picture the probable stages of development into the pastoral or nomadic, and the agricultural or settled modes of life. In countries affording abundance of grass, on which herds of wild animals fed, he was necessarily dependent on these animals, and became a herdsman; and as in such countries there was

no temptation to exchange his occupation, and often no physical possibility of doing so, as a herdsman he wandered, dwelling in tents, and feeding his stock by moving from old to new pasture lands, where a fresh supply of food could be procured. Even now there are numerous tribes in Asia and Africa in a nomadic state. The tent is a chief feature in this mode of life. One of the simplest forms of tent is the large branch of a tree, bent so as to form an arch, and then driven into the earth at both ends, with a cow-hide thrown over it as a roof. The Hottentots, and various wild tribes of Indians in the pampas of South America, dwell in habitations constructed on this plan. The greater number of these people, however, heighten the interior of their rooms by employing straight stakes, so driven into the ground as to converge to a point in the form of a pyramid. The bark of trees is much used as a covering by many of the North-American Indians. Tents, especially in summer, are in use among the nomads of the polar regions—the Esquimaux, the Tungusians, and the Lapps.

Although, whilst wandering as a herdsman, man continued to be in a considerable degree dependent on the spontaneous bounty of Nature, still he would naturally seek new and more convenient modes of supplying his wants. As soon as an acquaintance with metals enabled him to make better tools, he forsook the kind of life which afforded him but a precarious mode of subsistence, selected a spot where the soil was fertile and the water-supply abundant, commenced the cultivation of the cereal grains, and became an agriculturist.

It is to be noticed that while the three stages of the Hunting, the Pastoral, and the Agricultural states constitute the theoretical order of human social development, their retention or abandonment has been in a great measure dependent upon the climate and soil, and the species of animals indigenous to the locality; neither does either of the modes necessarily exclude the others. Thus, while the

grounds of the hunter would, as a matter of necessity, become circumscribed, and occupied by tribes devoted to pastoral and agricultural avocations, the great hunting grounds of the ocean would never be thus limited, and, accordingly, the sea-coasts have been inhabited from the most primitive period to the present day by men seeking their food in the great storehouse of the waters. Again, in parts of the Old World, the droughts which prevail for some portion of the year, converting the plains into deserts, render them unfit for agricultural use, and in such localities we find that a pastoral stage of society and a nomadic or wandering life still continue. In America, on the other hand, the native tribes passed from the hunting to the agricultural state without going through the pastoral stage, a fact due to the comparative paucity of ruminants, to the abhorrence which the American Indians entertain of milk, and to the variety of vegetable productions offered for their uses amid the perennial verdure of their great forests. South America is pre-eminently distinguished for its luxuriance of vegetation. Here, accordingly, the native from the first found his sustenance in the vegetable rather than in the animal world, and his steps in civilisation and in conquests over Nature consisted not so much in the domestication and nurturing of the beasts of the field, as in the tilling of the soil and in the fostering of the roots and fruits of his woodland world.

In all states of society except the nomadic, man has erected for himself a settled habitation of more or less solid and durable materials. This was constructed first of wood, afterwards of uncemented stones. His dwelling-places combined the two qualities of stability and strength, and afforded him not only security against the weather, but served, in some sort, as a fortress against the attacks of enemies.

Among the most ancient forms of fortified dwellings known to archæologists are the already mentioned lake-habi-

tations of Switzerland. These were beehive-shaped huts, elevated on piles a little above the shallow waters, and in appearance like those now erected by the natives of the Papuan Archipelago. Sir John Lubbock, in common with other archæologists, has divided them into three classes:—"Firstly, those in which all the instruments discovered are made of stone and bone, and which may therefore be said to belong to the Stone Age; secondly, those in which objects of bronze occur, which are more numerous; and, thirdly, those in which implements of iron have been discovered, only a few of which are known." Near the sites of these dwellings, fragments of wood and cinders have been found, together with a curious assemblage of objects of art in bone, stone, and bronze. Some specimens of pottery, made of coarse clay mixed with sand, have also been found, the pots being ornamented with stripes, and possessing small handles.

The oldest stone buildings known are without cement. In Europe and America colossal structures of this character have been discovered, consisting of huge, variously-shaped, superimposed pieces of rock. Extraordinary strength must have been necessary to elevate them and place them in their appropriate positions. The pre-historic masses of masonry at Tiryns, in the Peloponnesian structures known as Cyclopean, afford an example. They consist of walls and galleries, formed of immense polygonal uncemented blocks of stone, held together by their own weight, and having their interstices filled with smaller but equally rough stone masses. Many such, and notably those of Tiryns and Mycenæ, were early provided with coverings formed by the overlapping of the stones in the walls, or the mutual inclination of large blocks. These architectural works belong to a very early period, no record concerning them having been handed down.*

* On this subject see further: "Pre-historic Man," by Dan. Wilson, 1862; "Researches into the Early History of Mankind," by E. B. Tylor, 1871.

CHAPTER II.

The Useful Arts as known to the Ancients:—Babylonians, Assyrians, Egyptians and Phœnicians.

The countries inhabited by these nations were the original homes of human art and industry. Their history extends from the earliest times of which we have any authentic record to the third century before the Christian era. Here arose edifices of a purely primitive type, and of a perfectly original design; gigantic cities, such as Nineveh and Babylon, were reared, occupying from eight to nine leagues of territory. Even at this early epoch a degree of civilisation existed which must have been the result of several ages of progress.

SECTION I.—THE BABYLONIANS AND ASSYRIANS.

Babylonia and Assyria were the centres of a government and a commercial activity which extended from the Indus to the Mediterranean, and from the Indian Ocean to the Black Sea.

A high road from India, through Persia, to the shores of the Mediterranean, was traversed by numerous caravans and camels during the time when the Assyrian and Babylonian empires were in the height of their splendour, considerably more than 2,000 years ago. In modern times we behold Mohammedans making, along the same tracks, their pilgrimage to Mecca. Large public buildings, now called caravanserais, were erected at different points along the route, and these are the oldest inns of which we have any historical record.

Yet this ancient Assyrian valley, once so fertile and thickly-populated, has been desolated, and nothing is left but the ruins of its former magnificence. From these ruins, however, we learn the high state of perfection to which the Assyrians carried the industrial arts. Potters made vessels of

every size and form, and bricks were enamelled. Beads, and other ornaments of variously-coloured glass, have been discovered, attesting their knowledge of the fictile art. Workers in metal manufactured kettles, dishes, bells, and cups; lapidaries, jewellers, and goldsmiths worked most skilfully in marble, agate, and carnelian; and there were not wanting makers of needles, earrings, hooks, buttons of ivory and mother-of-pearl, together with metal rosettes and artificial objects of copper. Sculptors, stonemasons, and bricklayers were skilled in their respective arts; and we find, as works of their hands, arches, both rounded and pointed, marble staircases, and walls covered with monumental and historical sculptures.

The Assyrian palaces were partly built of stones, held together with mortar; partly, too, of bricks cemented with bitumen; and here for the first time the work of the stonemason and builder is conspicuous. Around these immense structures cities and towns arose, many of which, as is evident from their ruins, were formerly scattered through the Valley of the Tigris and Euphrates. Some of these cities, as Nineveh and Babylon, were possessed of palaces more than a mile in circumference, encompassed with walls, and raised thirty or forty feet above the level of the surrounding district. The object of such an elevated position was to ensure a cooler atmosphere, and to give to the buildings dignity and means of defence. The princely Temple of Belus, built by Semiramis, wife of Ninus, one of the Assyrian kings, an edifice which has never since been excelled, rose on eight such terraces to a height of 569 feet. The materials employed were sun-dried bricks, in regular layers, cemented together with bitumen, which soon hardened to a much more solid substance than the clay and straw of which the bricks were formed.

The famous hanging-gardens, constructed in Babylon by Nebuchadnezzar to please his queen, appear to have been marvels of horticultural skill in landscape gardening,

as well as in the cultivation of flowers, trees, and shrubs. According to Diodorus and Strabo, the form of these gardens was square, and the terraces on which they were laid out rose to the height of more than 300 feet. They were still in existence in the time of Alexander the Great, who was astonished at their grandeur.

Arches were skilfully built of brick, and rollers and levers were used for moving and elevating masses of stone. The processes employed are minutely depicted in relief on the marble slabs brought from the walls themselves, and now deposited in the British Museum and the Louvre. Even at this early period the craft of the mason had advanced to the higher kinds of sculpture, and not only the arts of peace but those of war—the arms and exploits of princes and heroes—were the subjects of representation. The excavations which have yielded these samples of Assyrian skill have been chiefly carried on at Nimroud, Khorsabad, and Kouyunjik. Rich and Niebuhr, Botta and Layard have especially distinguished themselves in this branch of archæological research.

SECTION II.—THE EGYPTIANS.

Agricultural Arts—Architecture, Sculpture, and Domestic Furnishings—Arts relating to Textile Fabrics, Leather, &c.—Arts relating to Metals—Music, Letters, and Astronomy.

The commencement of the Egyptian historical period dates from the reign of Menes, the first king, B.C. 2412; but Lesueur places it at B.C. 5773, while Bunsen assumes it at B.C. 3643. In either case, the history of Egypt extends into very remote antiquity.

Burgsh is said to have brought from Egypt an old manuscript upon leather 4,000 years old. The records of Egypt disclose a degree of cultivation and refinement, apparently acquired by self-tuition; for we have no record that the Egyptians ever learned from any other nation. How many years must have passed away before they could have

become a mighty nation, and acquired a knowledge of the artistic sciences requisite for the conception and execution of the stupendous monuments and works of art still extant, cannot be determined. The fabulous chronology of the Egyptian priests embraces, according to recent investigations, 20,840 Julian years anterior to Menes.

However this may be, it was somewhere between the twentieth and tenth centuries before Christ that the pyramids, obelisks, temples, and palaces, even now so admirable in their ruins, were reared. There must have existed then as many distinct crafts as there were necessaries of life. Goldsmiths wrought chains for the forehead, as well as earrings and necklaces; there were also farmers, spinners, weavers, rope-makers, tanners, joiners, wheelwrights, carpenters, stonemasons, brick-burners, potters, glaziers, bakers, cooks, butchers, sandal-makers, basket-makers, and dyers, supplied with spindles, looms, axes, chisels, hatchets, saws, and most of the implements now in use. Let us consider in detail some of these branches of industrial art.

Agriculture.

The Valley of the Nile is well-fitted for the experimental operations of a primitive agricultural people. The alluvium deposited periodically by the overflowing of the river left the lands of the Egyptian husbandman enriched, and in such a condition as to be cultivable almost without the aid of mechanical appliances. But as the cultivation of the soil necessarily requires some tools, so the introduction of the plough was probably coeval with their early attempts to raise corn. The primitive ploughs, as depicted upon the Egyptian monuments, were little more than mere scratching instruments. The coulter and the share were in one, and the plough was constructed without wheels; its use, therefore, involved a large expenditure of labour, and it was fitted merely to tear open the ground, and not, as is the case with modern ploughs, to bring the subsoil to the surface. As the

population increased, corresponding advances were made in the agriculture of the Delta, by great works for both drainage and irrigation, and by improvements in the plough. In 1 Sam. xiii. 20, that implement, as used in the immediate vicinity of Egypt, is described as having both a share and a coulter, indicating, consequently, a considerable step towards an efficient machine.

The early Egyptians possessed a degree of agricultural knowledge superior to that of many subsequent centuries, and which might even be compared, as regards its absolute results, with that of our own country in the middle of the last century. The great fertility of Egypt and Babylonia, where returns of sixty, seventy, or a hundred fold were obtained, was due doubtless to irrigation, and to the influence of a sub-tropical climate. They used cattle-power at the earliest periods; but, as usual where labour is cheap and the population large, manual labour must have been also extensively employed.

Though the Egyptians seemed to have brought agricultural art to a condition unsurpassed till much later times, yet the rudest methods in the cultivation of the soil continued to be followed by neighbouring nations, and in some cases even by themselves. Herodotus informs us that in Egypt, when the fields have been irrigated by the flood of the river, "each man sows his own land and turns swine into it; and when the seed has been trodden in by the swine, he afterwards waits for harvest-time, and then, having trod out the corn with his swine, he gathers it in." The practice of employing oxen to trample the wet ground, over which grain had been previously scattered, is also described in Isa. xxxii. 20, and is still prevalent in parts of Hindostan, and in Timoor, one of the Dutch colonies in the East Indian Archipelago. The Israelites used no flail, oxen being employed to separate the chaff from the cereal grains—a mode which has been very general in all ages, as it now is in Syria, Spanish America, and even in Portugal. It is sometimes modified

by the cattle drawing a sledge or block of wood over the corn on the threshing-floor. These and other agricultural operations have remained unaltered, without any successful attempts at improvement, for 2,000 years, in several parts of the now civilised world. The Indian implements of the present day may be taken as the type of those used generally in most agricultural countries in ancient times. They are—a wooden plough, the point sometimes armed with iron; a wooden harrow, or large rake, the points sometimes of iron; and a sort of hoe, of various sizes, similar to the rake-harrow, but with an iron knife-edge instead of prongs. Reaping, both of corn and grass, is performed with the sickle.

The art of obtaining flour from corn, and making it into bread, was known to the Egyptians. This is evident from the oldest preserved monuments. On the slowly-perishing syenites and porphyrites are represented all agricultural processes, ranging from the use of the plough to the preservation and utilisation of the grain. Egypt was thus not only well cultivated, but seems also to have been for many centuries a granary for surrounding nations.

Beer, or *barley wine*, is spoken of by Herodotus (B.C. 444) as the common drink of the country. With this various herbs were mixed, to promote its fermentation, and to give it an agreeable flavour. The Egyptians attributed the invention to Osiris. The truth may be that Osiris was one of their princes, who taught the people agriculture, reclaimed them from barbarism, and was afterwards deified.

Herodotus also tells us that the sacred groves or gardens of the priests were extremely beautiful. They were watered by streams which, flowing from numerous fountains, diffused an agreeable coolness throughout the atmosphere. Avenues of fig and mulberry trees were common, and the stately palm tree added its graceful decoration. A wall picture of an ancient Egyptian garden has been preserved. It is square in form, is surrounded by a fence, and has rows of trees trimmed into the shape of balls; a vine arbour is in the

centre, and on the remaining spaces are square plots filled with shrubs and flowers. In connection with garden culture, it may be mentioned that on the outside of the Pyramid of Cheops an inscription has been discovered, recording the various sums of money expended during the building of the work, and informing us how much was paid for the radishes, onions, and garlic consumed by the workmen.

Cattle-rearing formed an important branch of Egyptian agriculture. On the early monuments cows are represented which must have belonged to an exceedingly fine stock, as also stately bulls, adorned with collars and bells. Scenes from their slaughter-houses and kitchens are also figured on some of the sarcophagi. Beef, as an article of diet, was restricted to the priests. Extraordinary homage was rendered to the ox; it was considered the emblem of agriculture, and altars were erected in its honour at Memphis and Heliopolis. The pig was deemed unclean, and even its presence was defiling. It becomes a question, then, why it was reared. Was its flesh eaten by slaves? Were hogs kept as scavenger animals?

Public Architecture.

The Brickmaker.—Bricks of sun-dried clay were very early employed in the construction of human habitations. Geologically, it may be inferred that alluvial countries, deficient in stone, would be the first scenes of brick-making; and, from their general suitability in other respects, it may be conceded that these tracts are among the earliest seats of organised society, from which have radiated the streams of agriculture, commerce, and the mechanical arts. Indeed, the most ancient monuments of civilisation have chiefly been found in the valleys of the Nile and the Euphrates.

The first record of brick-making (B.C. 2247), informs us that the bricks—in the Euphrates valley—were burned "thoroughly" (Gen. xi. 3); and it may be presumed that

this process was an improvement brought about by time upon those rude bricks which, in the first instance, would merely consist of dried clay. But from the next record of brickmaking contained in the early chapters of Exodus, about 750 years later, we infer that the Egyptian bricks were simply baked in the sun, and their tenacity aided by chopped straw or stubble, mixed with the clay of which they were composed.

The Biblical account of the manner of making bricks is expressly alluded to by Philo, a native of Alexandria, who in his "Life of Moses," describing the oppression of the Israelites, says that some were obliged to work in clay, and others to gather straw for the formation of bricks, "because straw is the binding of the brick." Philo's account is confirmed by Dr. Shaw ("Travels," p. 136), who says that "some of the Egyptian pyramids are made of brick, the composition whereof is only a mixture of clay, mud, and straw, slightly blended and kneaded together, and afterwards baked in the sun. The straw, which keeps the bricks together, still preserves its original colour, and this fact also seems to be a proof that these bricks were never burnt or made in kilns." Similar bricks are now used for building in Egypt, and they are also known in Mexico and Central America, under the term "adobes." That the Egyptians dried their bricks in the sun, rather than burned them in the fire, is no doubt due to the circumstance that, although Egypt was a corn country, and is so to this day, it is not, and probably was not then, a country abounding in any fuel serviceable for the kiln process; and the presence or absence of fuel is probably the immediate cause of the varying degrees of perfection to which the art of brick-making arrived in different localities. Indeed, it is said that no clay was burnt into bricks in the Valley of the Nile till the time of the Roman power in Egypt. But there are in the British Museum two baked Egyptian bricks; one is a small, rectangular brick, brought

from the Theban tomb which bears the name of Thothmes, a superintendent of the granaries of the god Amun Ra. The style of art, the inscription, and the name distinctly shows that it is as old as the eighteenth dynasty (about B.C. 1450). The other bears an inscription, partly obliterated, but ending with the words "of the temple of Amun Ra," and referred conjecturally by Mr. Birch to B.C. 1300. Sir Gardner Wilkinson obtained pieces of mortar from each of the three great pyramids, in which bits of broken pottery and of burnt clay or brick were embedded. These and other similar evidences prove that the ancient Egyptians, though they generally used sun-dried bricks, yet also practised the art of burning the clay for their superior buildings.

The Mason.—The Egyptian style, unique in itself, is, however, chiefly remarkable for its magnitude, magnificence, and durability. The oldest edifices of this type are the pyramids, and the great temples and temple-palaces of Karnak and Denderah. Such colossal structures could not have been raised without the aid of machinery, although, unfortunately, no historical record has been preserved of the exact nature of the appliances used. It is the general opinion of all historians that the machines employed were of the rudest kind. The heavy blocks of stone were probably drawn up on inclined planes of solid masonry, and sometimes of earth, by the manual labour of slaves, the earth being removed when the stones were in position.

An interesting design in a wall-relief still exists, which vividly portrays the mode adopted in moving a colossal statue. The enormous mass is being drawn by eighty-eight men, who, placed in four rows, are guided by a master standing above them; others are driving them forward with sticks, and urging them to put forth their utmost strength. We have here monumental proof that these monstrous structures were erected by slaves, and that they are fearful records of human toil directed to little or no

useful purpose. Wooden levers appear also to have been used.

The pyramids are now known to have been the sepulchres of the Egyptian kings from the third to the twelfth dynasty. This usage was afterwards abandoned, and the building of pyramids discontinued in Egypt. They are four-sided structures, square in plan, and triangular in elevation. Their sides face the four cardinal points, and form equal and similar triangles, which meet at the top in a point. The stability of this architectural form, together with the durability of the material used, has bid defiance to the elements for ages. The grandest pyramid, that of Cheops, is the largest building known. It had formerly a base of 746 feet square; but this has since been diminished by continued spoliation, the stones being removed for the purpose of building the city of Cairo. Its ancient height was 480 feet, at present it is only 450; it consists of 203 layers of stone. Its upper story is 31 feet in diameter, and its base covers an area of $12\frac{2}{3}$ acres. It contains at present 82,111,000 cubic feet of masonry, and its weight is estimated at 6,316,000 tons. The whole is constructed after the manner of steps, each successive layer forming one. These steps decrease in height from the bottom to the top, from 4 feet 10 inches to 2 feet 2 inches, and the stone blocks are 9 feet long and $6\frac{1}{2}$ feet broad. The ascent is fatiguing, but not dangerous, the summit having often been reached by ladies. According to Herodotus, 100,000 men were employed for twenty years in building this pyramid, the outside of which was cased with large and closely-jointed stones. The labourers were relieved every three months by a fresh relay. Considering the distance of the quarries, the weight of the material, the height of the structure, and the absence of machinery, this statement is not at all incredible.

Besides the pyramids, other enormous buildings, such as palaces and temples, were erected by the ancient Egyptians.

There is a room in the palace of Karnak 338 feet long by 170 feet broad, with 134 pillars, the thickest of which are 11 feet in diameter, and have capitals with a circumference of 64 feet. On the area covered by each of these pillars, 100 men could stand. The effect of this vast grove of columns is said to be surpassingly grand. The length of the entire palace is upwards of 1,200 feet, and its breadth varies from 321 to 360 feet. The gates, halls, and pillared areas of this and other palaces and temples, such as that of the great Ammon, in Luxor, were of corresponding magnitude. All these noble structures were adorned with statues and sculptured reliefs; a thick layer of mortar having been first superadded to the surface of the wall. These reliefs, like those of the Assyrian palaces, represent the myths of the country and the history of its wars. The statues are of very hard stone, either basalt, syenite, or porphyrite, and are frequently of immense size.

No trace of arches has been discovered in these buildings, the stones lying at right angles upon walls, pillars, and shafts. There remain evidences, however, that the Egyptians possessed a knowledge of the arch. Thus, at Sakkara there is in a tomb an arch of stone, with the name "Psammeticus II." (B.C. 600) engraven on it; and at Thebes, in another tomb, there exists a brick arch belonging, according to Wilkinson, to the reign of Amunoph I. (B.C. 1540). Many of these tombs have their walls covered with paintings and hieroglyphics of much historical value.

EGYPTIAN SCULPTURE.

It is impossible to assign any definite date to the origin of Egyptian sculpture. The limited period usually fixed upon is without any scientific authority. The art has been traced back to the reign of Osirtasen I. (B.C. 1700); but at this date the sculpture of the country had really arrived at its highest stage of development, and there must have previously elapsed a long interval during which it was progressing.

Of this interval itself, we have no authentic history. It is certain, however, that from the reign of Osirtasen I. to the time when Egypt became a Roman province, the style adopted by the sculptors underwent no change. From monumental remains which are extant, it is not difficult to trace back sculpture in general to its earlier elementary essays. Rude outlines on the smooth surface of a rock were the first efforts of the chisel; next an attempt was made to give to the figure or groups of figures roundness and relief, and when this was done, the carved mass was separated from the original rock. Egyptian artists, however, seldom advanced so far as to complete the sculpture of their figures behind—nearly all are rock-bound. Their statues never start free-limbed and life-like from the stone, and herein lies their difference from the finished specimens of Greek and Roman art.

Domestic Architecture and Furniture.

History, so far as it can be traced back, indicates that ancient Egypt was the birthplace of the mathematical and mixed sciences. Many centuries before the Christian era, the carpenter's art was established on the basis of geometry and calculation. All the implements necessary in the construction of buildings were known to the Egyptians. They had variously-shaped axes, the blades of which were fastened to the handles with thongs, as well as chisels, mallets, planes, and single saws. Nor were the superior instruments wanting, for levels, rules, levers, rollers, wheels, and pulleys have also been found. In ancient Thebes there were houses with several rooms, usually on the same floor, although in some rare instances there were two or even three storeys, the rooms in the upper part of the house being used as bed and living rooms, whilst those on the ground floor served for stores. An ordinary dwelling-place had nearly always a fore-court, containing a few trees, with a tank or a fountain in its centre. The ceilings rested on

pillars, and the roof was supported by rafters of date palm. An open terrace, overspread by an awning of cloth, was usually connected with the house. Beneath this the inmates, while enjoying the air and light, could protect themselves from the sun's rays, and avail themselves of the coolness when the nights were close or hot. There is abundant evidence, from their monuments, that the Egyptians held assemblies and banquets, and had beautifully-ornamented saloons set apart in their houses for festive occasions.

The workshops, tools, and labours of joiners and cabinet-makers are represented on Egyptian monuments. Taking one as a sample, we find the master delineated as boring with a drill into a chair-frame, whilst his assistant is polishing one of its beautifully-carved legs; another representation is of a workshop, containing axes, planes, saws, chisels, and gimlets.

The apartments of a house belonging to a man of rank contained all kinds of joiners' and cabinet-makers' work. The doors were richly carved, the ceilings and walls of the rooms beautifully painted, and the floor covered with mats. Coloured vessels, containing flowers, stood upon light and elegant stands. Foot-stools with three or four legs, chairs with and without backs, sofas, arm-chairs, and tables of various forms found place in their rooms; and besides these were other articles of furniture delicately cut, inlaid, and painted. The Egyptians, nevertheless, seem to have been unacquainted with the art of turning, the legs of their tables, chairs, and sofas being angular instead of rounded.

Pottery.

The Egyptians employed numerous vessels made of excellent earthenware, painted, glazed, and decorated. The colouring matters consisted of ferric and cupric oxides, which were baked into them; and the glazing was produced by means of a vitreous coating, mostly applied with salt. The glazing of bricks was practised at least 800 years

before the Christian era. The glazes of the Assyrian and Babylonian bricks consist of sodic silicates, or soda glass, coloured with stannic oxide, plumbic antimoniate (Naples yellow), and also with copper. The fragments of porcelain which have been found belonging to these early times, seem to indicate that a traffic must even then have been carried on between China and the West.

Terra-cotta, which literally signifies baked clay, is the term applied to ancient pottery in the form of vases, amphoræ, pateræ, lamps, statues, and bas-reliefs. Terra-cottas are found throughout ancient Egyptian cities in vast quantities. Their forms are particularly beautiful, and some are painted black, some red, most frequently on a buff-coloured ground. Upon the walls of ancient Egyptian buildings there are paintings of vessels used for cooling water, which were made of a fine porous clay, lightly baked, and very thin, and the shapes of which are very elegant. There are also paintings representing the manufacture of such articles of pottery. These show the entire process, from the kneading of the clay to the baking of the wares, and on them is seen the ordinary potter's wheel now used, with the difference, however, that whilst the wheel of 3,000 years ago was put in motion by the hand, its modern type is worked by the foot.

Glass-making.

Glass-making was certainly known to the Egyptians, and the discovery of the art is ascribed to Hermes and others. Glass-blowing is represented on one of their oldest monuments. Two men, with long reeds dipped into the glowing and melted matter, are figured in the act of blowing large *amphoræ*, or Egyptian flasks. All kinds of glass vessels were made, such as plates, cups, lamps, bowls, bottles and drinking goblets, together with artificial jewels, the hues of which they were able to imitate. Examples preserved in their tombs also give evidence that this people were familiar

with the processes of pressing and moulding glass. Glass windows and mirrors were, however, unknown to them. Lattice-work, which the wind penetrated, supplied the place of the former, polished metallic plates that of the latter. Among the ruins of Thebes, pieces of blue glass have been discovered; and Strabo speaks of celebrated glass-houses at Alexandria and in the Thebaid.

The Arts Relating to the Treatment of Fibres, Skins, &c., Known to the Egyptians.

Weaving.—Weaving was an art in which the Egyptians excelled. Their oldest monuments depict women spinning threads of wool from a distaff. Looms also, both horizontal and upright, are represented. Their woollen, linen, and other fabrics were of such good quality that the renown of Egyptian textures spread through the known world. Coloured, striped, and spotted cloths were made into curtains, cushions, beds, and table covers. The fine linen of the country was elastic, close, and firm, and its durability is proved by the still existing cerements of the most ancient mummies. These mummy cloths present us with perfect specimens of several varieties of linen. One of the most delicate contains to every square inch seventy-one threads in the weft, and one hundred and fifty-two in the warp; and the yarn of which it must have been composed is computed at more than one hundred hanks to the pound.

Dyeing.—The art of dyeing was in high esteem. Striped, checked, and figured attire, in single colours, distinguished their eminent personages. Many of their cerements had a blue border, the colouring matter of which has been proved to be indigo. Pliny describes their methods of dyeing with so much exactness that his accounts would apply to the processes of modern dyers. The stuffs, he says, were dipped into hot fluids, and, on being withdrawn, shone with various colours.

Rope-making.—The Egyptians made ships' cables from

the fibres of the flax plant, which grew abundantly in the Valley of the Nile. A representation is extant of a rope-maker at work with his assistants. The men are kneeling, and fastening together the threads of which the rope consists, whilst their master is standing, grasping and twisting it with both hands. When made it was wound into coils, and stored in a magazine. Strong ropes must have been used in the construction of the pyramids, and in the removal of colossal statues. Through the same means, also, boats on the Nile were towed up the stream.

Leather-dressing.—A special part of the city of Thebes was allotted to curriers, who prepared the skins not only of the domesticated ass, horse, ox, sheep and goat, but also of wild beasts, more particularly those of the lion and leopard. The process was similar in principle to that of modern tanning. The desert was searched for plants whose acid secretions and extracts had the property of changing the gelatinous skins into an almost indestructible leather. Cross bands of this material, in excellent preservation, with inscriptions upon them indicating an age of 4,000 years, have been found upon mummies. The peculiar ingenuity of the Egyptians as curriers was conspicuous in many ways besides that of their clothing. They made not only shoes and sandals, but also covers for their sofas and chairs, and ornamental devices for their harps. Leather, too, was employed for their dagger-sheaths and quivers, for shields, and helmets, and for water and wine vessels. The ordinary shoes were tastefully pointed, but were worn only by people of quality. Representations exist of lasts and awls, together with hones for sharpening the shoemaker's semicircular knives, but nothing is delineated of shoemaking as a craft.

Saddlery and Harness-making. — The Egyptians were skilful manufacturers of riding gear, and harness. Horses and chariots were only used in war; but on one monument we see, in company with a cartwright, a man measuring the

width of a chariot with a flexible net of leather, and on another we have an ancient Egyptian warrior galloping to battle on his war-car. The yoke rests on a covering which is thrown across the backs of the foremost horses, each saddle being fastened to the body of the animal by means of a belly-band and a strap around the chest. The bridle is of various colours, and is fastened to the snaffle. The whip, which is straight, seems to be composed of leather.

Costume of the Egyptians.

The coifs of linen worn by the Egyptians, were rendered attractive by their brightness of colour, which was green, yellow, or white. The distinguished citizens, however, wore wigs or perukes made of wool, much as fez caps or turbans are worn now. Another form of peruke consisted of a network or braid. In front the hair was curled, but behind was allowed to hang freely down to the shoulders. Their martial head-gear was a light, striped helmet, fitting close to the head, and crowned with two tufts which waved over the neck. Only the leaders wore helmets of metal. Dress among the nations of antiquity was comely and beautiful. Homer celebrates the taste and skill which the Sidonian women displayed with their needles. It was a mark of distinction in Phœnicia, as also in Assyria, Egypt, and Persia, to wear beautifully-coloured garments, which usually hung in graceful folds down to the ankles, and were richly fringed with striped or embroidered borders.

The most scrupulous cleanliness of person was also studied among the ancients. The Egyptian priests shaved the body every three days, and frequently changed and washed their clothes. Probably, however, they knew nothing about soap, and used, instead, fragrant ointments made from vegetable or animal matters. With these they anointed themselves after copious ablutions. In the earliest periods clothes appear to have been cleaned by being

rubbed or stamped upon in water, without the addition of any substance whatever. According to Homer, this was the mode of washing amongst the early Greeks, and may also have been that used by the ancient Egyptians.

Egyptian use of Jewellery.—We learn from the Scriptures that ancient Egypt was rich in silver and gold. King Pharaoh "took off his ring from his hand, and put it upon Joseph's hand," "and put a gold chain about his neck"—a long-established fashion of conferring a royal honour, as is proved by the absence of comment. The Hebrews also borrowed before their exodus "jewels of silver, and jewels of gold." Further confirmation is preserved on their monuments, which portray a series of operations—the melting of the gold in crucibles, the heat being increased by men blowing through tubes; then the working of the same with tools; and, finally, the weighing of the metal by clerks. Statues of gold, silver or bronze, together with numerous vessels of like materials, are also depicted both in a finished and an unfinished state. Besides this, the tombs of Egypt have furnished examples of ancient art, from the custom of burying jewels with the dead. Amongst numerous ornaments thus preserved, there have been found diadems, necklaces, bracelets, and finger and earrings of excellent workmanship.

Arts relating to Metals as known to the Egyptians.

1. *Mining.*—The earliest records of mines are those of Egypt. According to the hieroglyphics in the Memnonium under the figure of the king, who is offering produce to Amun Ra, the gold and silver mines of Nubia are said to have yielded the improbable sum of 3,200,000 minæ, or £7,000,000 sterling. The work near Berenice was temporarily interrupted by the conquests of the Persians, under Cambyses (524 B.C.), but was resumed by prisoners when the war was over. In later times, as in the reign of

Ptolemy Dionysius (50 B.C.), when the ancient glory of Egypt was waning, digging in the gold-mines was still kept up.

2. *The Art of Smelting.*—In our notice of the knowledge of metals and metallurgy possessed by the ancient Egyptians, we shall briefly sketch what is known of ancient metal-working in general. The history of smelting dates from remote antiquity, and, as Le Play observes, "most of the fundamental phenomena of metallurgy were discovered, and regularly applied to the wants of man, before the physical sciences existed." The remains of ancient furnaces and metallurgical products have not unfrequently become the subjects of archæological inquiry; and it is interesting to trace the history of the smelter's art, noting how the rude and laborious processes of former times have gradually acquired the marvellous development of the present day. To form a clear conception of this progress, one has only to picture the Hindoo, toiling laboriously at his skin bellows to extract a few pounds of iron from his little furnace, and then direct attention to the gigantic blast-furnaces of modern times, urged by engines of a hundred horse-power, and each yielding upwards of 200 tons of iron in a week.

The dressing of ores in general, as practised by the ancients, may be best illustrated by the account given of Diodorus Siculus, who flourished under Augustus: "On the borders of Egypt and Arabia there seem to be spots very fertile in metals, from which, with much labour and expense, gold is obtained." The description of the operations is as follows: "The rocks, by great force being cut in pieces, are carried to the surface, where workmen reduce them to smaller pieces, which are then beaten in stone vessels, with a pestle of iron, to the smallness of millet seeds. They then, being cast into mills, are ground to the fineness of meal. Then the workmen remove the finely-triturated mass to inclined tables, and by means of water the earth is washed away, and the gold, by its gravity,

remains upon the tables. Lastly, the workmen do put it by weight and measure into earthen pots, and do superadd, in a certain measure, lead, sea-weed, and bran of barley. These things being compounded in a certain proportion, they diligently daub up the pots with clay. Furthermore, being decocted five whole days and nights in a furnace, pure gold is only found in the vessel." (Webster, 1671). The object of the final process was simply the fusion of the fine gold into one mass.

3. *Tin.*—Pliny refers to this metal in the 16th chapter of the 34th book of his "Natural History:" "The most precious of these, the *plumbum album* (tin), is called by the Greeks '*kassiteros*,' and is fabulously declared to be sought for in the isles of the Atlantic, to which it is brought in wicker vessels, covered with leather. It is now ascertained to be a native production of Lusitania and Gallicia; it is found in sandy-surface soil, is of a black colour, and only distinguishable by its weight. Small pebbles of ore also occur in the dried beds of streams. The miners wash these sands, and what subsides they melt in furnaces. It is also found with gold ore, in what are called stream works, the stream of water washing out black pebbles of the same weight as gold." That *kassiteros* was tin appears to be generally allowed, and the miner who knows the mode of its occurrence, and the character of the ore, will have no doubt that the *plumbum album* of Pliny is the tin of modern language.

Tin was in esteem during the Trojan War—Homer calls it *kassiteros*. The uses to which he puts it, in the breast-plates and shields of Agamemnon and Asteropous, and in the greaves of Achilles, are such as imply easy fusibility and ductility; they also indicate that the metal was highly valued, and almost precious. Why Pliny treats as a fable the story of the Cassiterides yielding tin it is somewhat difficult to say. The modern reader will at once detect in the wicker boats covered with leather the

coracles of the ancient Britons and Irish. Humboldt thinks that the Phœnicians, by means of their factories in the Persian Gulf, maintained a trade with India; and as the word "kassiteros" is the Sanscrit word "kashthira," he inclines to the opinion that the term "Cassiterides," or "land of tin," was in the first place applied to the islands of the Eastern Archipelago. Tin ore has long been obtained from Malacca and the adjacent islands.

It is extremely probable that the smelting of tin was performed by the ancient inhabitants of Cornwall, for all the accounts of the early tin trade represent the metal, and not the ore, as being carried away. Indeed, Diodorus mentions the weight and cubical form of the tin blocks carried from Vectis; and Pliny says of Gallician tin, that it was melted on the spot. Possibly, the art of smelting tin was brought from the far East, or introduced by the Phœnicians. It was, however, a step in advance of the fusion of native gold. The gold was fused in clay crucibles, but tin ore treated in this way would be infusible. It must be exposed at once to heat and a free carbonaceous element. Perhaps some accidental fire in the half-buried bivouacs of the Damnonii may have yielded the secret. As to the fuel, we are told by Pliny that pine woods were best for smelting brass and iron, but the Egyptian papyrus and straw were also in use.

4. *Use of Iron by the Egyptians.* — Amongst the Egyptians, the use of iron was preceded by that of copper or of bronze, of which they made their kitchen utensils and mechanical tools. Iron was eventually used for these purposes, but, from the few examples of the kind existing, as compared with those of copper, it is evident that the latter maintained its place in preference to iron through the whole period of the history of ancient Egypt. Scarcely any iron was found in the country, and the extra cost of importation tended to limit its use. The skilful inhabitants had also discovered a method of rendering copper hard, and capable

of bearing as fine an edge as steel, and the use of bronze tools in their sculptures has already been alluded to.

5. *Egyptian Cutlery.*—It is highly probable that the Egyptians were early acquainted with the use of steel. From their pictorial records we decipher the fact, that knives were part of the equipment of their butchers and cooks. Double-edged swords, an English yard in length, daggers and sabres, the blades and handles of which were variegated with bright colours, were the military arms in use.

6. *The domestic fastenings used by the Egyptians* were contrivances in bronze, curiously like some of our own appliances for domestic convenience and defence. Doors and gates were hung upon bronze hinges, and fastened with bolts. Coffers and trunks with lids were likewise in use for keeping supplies of linen and clothes. Wardrobes or cupboards with folding-doors were not uncommon, and the caskets for the jewellery of the Egyptian ladies were secured by means of locks. Denom has engraved a wooden lock, such as was in use at this period. The keys were of the simplest construction, being made merely to lift up or push aside the bolt.

7. *Arms and Armour.*—Monuments depict the arms, armour, and mode of warfare common among the ancients; and prove, on comparison with modern examples, that the manners and customs of the Orientals have been through all ages as unchanging as their stone records. The Egyptians marched to battle in close phalanx, armed with sabres, lances, slings, and clubs or battle-axes, and they cheered themselves onward by strains of martial music and by the beating of drums. The leaders wore armour and helmets of brass or bronze. The suits were made in overlapping scales fastened upon leather, and covered most of the body down to the knees, and the legs were protected by greaves. The ordinary soldiery, who were lightly clad, wore helmets of quilted linen, and defended themselves with wooden shields.

Music.

The fresco painting of a harp, found by Bruce in an ancient tomb near the ruins of Thebes, shows the progress made by the Egyptians in the art of Music. This ancient instrument, in its form, dimensions, and ornamentation, is so perfect, that it might very easily be mistaken for a harp of modern date.

The Egyptians had many of the wind, stringed, and percussion instruments at present known. Among the last were the cymbal, the drum, the tambourine, and one called the *sistrum*, made of brass. For wind instruments they had trumpets of metal, flutes, and tubes with several holes. They possessed also reeds of different lengths and diameters, which produced either high treble or bass notes. Stringed instruments, variously shaped harps, and oval guitars, were in use; the latter being usually played by women, whilst men performed on the former. Concerts were held on festive occasions, with the accompaniments of singing and dancing. Athenæus, describing a Bacchic festival given by Ptolemy Philadelphus, tells us that more than 600 musicians were employed in the Egyptian chorus, among whom were 300 performers on the cithara, or lyre. Music was especially cultivated by the priests, who understood the art of composing melodies and making them harmonious. We know absolutely nothing as to the nature of their musical notation.

Letters.

The important discovery of written language is fairly traced to the ancient Egyptian civilisation, the inscriptions on the tombs and monuments of ancient Egypt being the oldest known form of writing in the world. As deciphered in modern times, it consists of three varieties, of which the principal is the hieroglyphic, usually found engraven on public buildings and memorials, such as obelisks, the walls of palaces and temples, and in the interior of catacombs.

The other two characters are abbreviations of the hieroglyphic, and served for common use; they were written on the papyrus, a reed similar to that now used by the Orientals. The alphabet of these ancient inscriptions comprised altogether about 1,000 characters, consisting either of pictorial images representing the thing itself, or of symbolical illustrations. There were large libraries of papyrus rolls in the Egyptian temples, and in their treasuries and residences archives were kept, in which registers and the accounts of customs offices were preserved. The papyrus rolls were prepared from the cellular stem of the papyrus plant (*Cyperus papyrus*, L.), a species of sedge which formerly grew abundantly on the banks of the Nile. Its gradual disappearance from Egypt has led botanists to suppose that it was not indigenous, but introduced from the Niger or the Euphrates—where it is still found native—and that it has become extinct for want of culture. The layers of the stem of the papyrus were spread out into sheets, which, when subjected to pressure, became cemented by their own gum, and thus formed the first paper. These sheets, before the invention of book-binding, were made up in the form of rolls, and it is in this shape that writings are usually found. The term "biblion," whence the English word *Bible* is derived, means, really, a *roll* of papyrus.

Egyptian papyri are found under various circumstances, but principally in connection with mummies. The so-called Ritual of the Dead was a document always deposited with deceased persons of consequence. The material of these varies from a coarse and stringy substance to one perfectly smooth, silky, and of the finest quality; the length and breadth are arbitrary; the former ranges from a few inches to sixty feet and upwards, and the latter from four to eighteen inches. Under the Ptolemies, the successors of Alexander, a library was established in Alexandria, which contained in Cæsar's time 700,000 volumes, or rolls, collected from all parts of the known world. Recent dis-

coveries in Egypt have considerably increased the stock of these treasures, 146 having been found in the ruins of the Serapium at Memphis. They are now dispersed throughout the museums of Europe. Those which have been exhumed from the ruins of Thebes are very interesting, inasmuch as they throw considerable light on the history of that city and the manners and customs of its inhabitants. Some of them relate to the sale of mummies, others are advertisements for runaway slaves; one is a treatise on astronomy, another on grammar; one a book of the "Iliad;" one a horoscope, with extracts from lost authors. Other miscellaneous writings have also been discovered.

Astronomy and Mode of Measuring Time.

The Assyrian priests were so distinguished in the study of astronomy, that among ancient writers the word Chaldæan is often used for astronomer, or its synonym, astrologer. The destruction of Assyrian edifices has, however, deprived us of all means of ascertaining the extent of their knowledge. That the Egyptians paid attention to this science is proved by an ancient zodiac found sculptured on the ceiling of an apartment in the great temple of Denderah by General Desaix (A.D. 1798) when the French army under his command invaded the country. The Egyptians had no true idea either of the mechanism of the heavens or of the spherical form of the earth, and knew but little of the properties of matter—solid, fluid, or aëriform. Long measuring instruments are met with in Egypt, made of talc and wood, and carefully graduated into halves, thirds, fourths, and fifths of an inch. Such standards were set up along the whole course of the Nile, to mark the annual changes of level in the river.

The instruments first used for the measurement of time were the sun-dial and the clepsydra (Gr. *κλεψύδρα*, "water-stealer"), or water-clock. This latter was invented by the Assyrians at a very remote period, and its origin dates further

back than that of the sun-dial. The apparatus existed before the overthrow of the first Assyrian empire by Arbaces, King of Media, somewhere about 759 B.C., and its use was general in Nineveh under the rule of Phul, better known as Sardanapalus II., the first monarch of the Second Assyrian Empire. The Assyrian clepsydra was a brazen cylindrical vessel, holding several gallons of water, which gradually emptied itself drop by drop through a small hole. The Royal Palace of Nineveh and the principal districts in the city were each furnished with one of these water-clocks, all being as nearly as possible of the same shape and capacity. At the signal of a watchman placed on a high tower to proclaim the rising of the sun, all were filled, and remained during the day in the keeping of officials, whose business it was to see them re-supplied as soon as empty. Whenever the filling was accomplished, another set of officers announced the fact in the city, and in this way a sort of rough calculation of the time was kept. The intervals between the filling and emptying were called watches, and were probably of two hours and a half in duration. Clepsydras were first used in Egypt under the reign of the Ptolemies. The invention of the Egyptian clepsydra is ascribed by Vitruvius to Ctesibius, of Alexandria, who lived in the reign of Ptolemy Euergetes, about 140 B.C. This instrument was a much more elaborate contrivance, for it showed not only the hours, but the days of the months, and even the zodiacal sign of the sun. Another clepsydra, more generally used by the Egyptians, was much simpler in its structure. It consisted of a jar containing water, which slowly escaped through a hole in the bottom, while the oar of a miniature boat, which floated on the surface as it sank with the fall of the water, pointed out the hours, which were marked on the side of the jar. Egypt afterwards became the great mart for clepsydras, exporting them at fabulous prices to the different countries of the East, as rare curiosities.

The Egyptians made use of their obelisks, we are told,

as dials, and measured the time by the varying lengths of the shadows which they cast. Certainly, the pyramids were always erected in the direction of particular points of the heavens, and were especially fitted for their purpose by the regularity of their form and the exactness of their proportions. The Egyptians, moreover, divided the day and year as we do now, since they understood how to calculate time with tolerable accuracy from the appearances in the heavens. Besides these obelisks, there were also portable sun-dials made of stone, on which the hour-lines were drawn, and on which the shadow of the style fell when the sun shone. This style was set up vertically on the plate due north and south, or in the line of the meridian.

Another ancient mode of measuring time was by means of sand, which is preferable to water, inasmuch as it flows through an orifice with nearly uniform velocity, the pressure among its particles not being transmitted in all directions, as is the case with water. Both in Egypt and Greece sand-clocks were known in very early times. They were similar to the modern hour-glass in the principle of their construction. The sand-clock of Archimedes is described as consisting of two glasses, the sand slowly falling from one into the other.

SECTION III.—THE PHŒNICIANS.

From Babylonia, Assyria, and Egypt, civilisation was spread, through the agency of the Phœnicians, westward along the Mediterranean to the shores of Britain. Tyre and Sidon were the two chief centres of Phœnician industry. In Tyre itself there were important manufactories of glass, and ornaments such as girdles, buckles, metallic mirrors, rings, head-bands, veils, and the far-famed purple robes. Pliny states that the Phœnicians obtained their renowned purple dye from two kinds of mollusks, or shell-fish, which he designates as the *purpura* and the *buccinum*. Only a single drop of the finest colour was extracted from each animal;

but a cheaper dye was then obtained by crushing the remaining substance and adding salt. Wool steeped with the prepared fluid did not assume a purple tint till after exposure to light and air for two days. During this time it went through a gradation of shades of lemon-colour, green, blue, violet, and red, which the Tyrians appear to have known how to arrest and fix at any point of the process. A story gives the credit of the discovery of this dye to a sheep-dog, whose mouth was coloured a beautiful red, by his having bitten the shell of a *purpura*. The Phœnicians acquired their knowledge of glass-making and enamelling from the Assyrians, and had manufactories in Sidon and elsewhere. The art afterwards reached the Greeks, but was little used by them till the time of Alexander. The Phœnicians wrought gold and silver vessels with very great skill. The profusion of these vessels and of precious stones in their cities is dwelt upon in Ezekiel's denunciation of Tyre, wherein emeralds, coral, and agate are included in the merchandise from Syria, and the merchants of Sheba are said to have occupied in the markets with all precious stones and gold. Still more striking is the description of the King of Tyre—"Every precious stone was thy covering, the sardius, topaz, and the diamond, the beryl, the onyx, and the jasper, the sapphire, the emerald, and the carbuncle, and gold." * In addition to the assistance rendered to Solomon by the Tyrians in the casting of his brazen works, to which reference has already been made, we have it on record that they rendered him valuable aid in his preparations for building. Homer, too, in his descriptions bears vivid testimony to the skill and genius of Sidonian artists.

The mountainous character of Phœnicia rendered it but little adapted for agriculture; and it was, therefore, mainly dependent upon the neighbouring states for its food-supply. Carthage, colonised by the Phœnicians, was, however, more favourably circumstanced, and agriculture was

* Ezek. xxvii., xxviii.

considered by its inhabitants to be a most honourable employment. Mago and Hamilcar devoted to agriculture the leisure which their profession of arms left them. The former, called the *Father of Husbandry* by Columella, wrote a work on Agriculture in twenty-eight books, in which he treats in a detailed manner of the breeding of horses and mules, of the rearing and fattening of cattle, poultry, pigeons, &c.; the cultivation of the vine, olive, and almonds; the planting of poplars and other trees; the production of wine, and the care of bees. Other Carthaginian writers (550—480 B.C.) evince an acquaintance with every branch of husbandry.

The Phœnicians initiated the first successful commercial intercourse among nations, and their skill in shipbuilding, and in the art of navigation, must have been pre-eminent. We are indebted also to this remarkable people for the diffusion of the art of alphabetic writing. Few ancient peoples have done so much towards the civilisation of mankind as this little country skirting the east coast of the Mediterranean.

SECTION IV.—THE HINDOOS AND CHINESE.

THE HINDOOS.

"The general opinion of ancient as well as of modern times is unanimous in considering the Hindoos as one of the earliest, if not in fact the oldest, civilised nation in the world . . . At the period of the Macedonian invasion (nearly 350 years before Christ), the Hindoos already appear to have reached that degree of refinement and civilisation, both in public and private life, which they subsequently maintained. We are, therefore, fully authorised in the conclusion, that this civilised state must then have been several hundred years in existence."—*Heeren.*

Consequently, from the stationary position which Hindoo civilisation has held from very early-recorded times, industrial arts among the ancient Hindoos may in a great measure be exemplified by their condition at the present day.

There are many very remarkable points of resemblance between the ancient Hindoos and Egyptians, and what has been said of the latter in respect to their technical history applies, with certain limitations, to the former. The monuments still extant in Indian architecture are scarcely less important than those in the Nile Valley. The predominating taste was the pursuit of architecture and its cognate art, sculpture. The most ancient class of buildings are the Buddhist cave-temples and habitations excavated in the heart of rocky mountains, but these are not supposed to be older than 250 or 300 B.C. Agriculture was the principal occupation of the people, and especially directed to the supply of wheat and rice. The art of weaving cotton was also an important industry. Their practice in these arts, and the tools and implements employed, were identical in both nations. The extraction of copper and iron from their ores was practised by the Hindoos from a very remote period; and it was a process in which they attained great skill, Indian steel having been an article of trade many years before the commencement of our era.

THE CHINESE.

According to the earliest records, the Chinese possessed, in remote ages, a degree of civilisation equal, if not superior, to that of many subsequent centuries—an observation applicable to the Hindoos, Assyrians, and Egyptians.

Like every ancient people, the Chinese possess also their fabulous and semi-historical periods. The latter commences with Fohi, the first emperor, between 3,000 and 4,000 years before Christ. Several of his descendants are named who made discoveries in the arts. The historical period commences with the first king, Hoang-ti, about 2,700 years before Christ, according to Lepsius's computation. Strong evidence as to the antiquity of a nation is derived from the evolution, progress, and development of their language.

That of the Chinese is in the earliest, though it has arrived at a systematic stage. Bunsen, who, with many others, assumes one primitive language, observes: "Philosophical inquiry shows that the monosyllabic or particle language, as preserved in the ancient Chinese, must be supposed, theoretically, to have preceded the organic language; and either each language, separately, must once have been like the Chinese, or the Chinese itself is the wreck of that primitive idiom from which all organic languages have physically descended."

It is certain that art and science flourished in China at a long-distant period; and that the Chinese possessed a high degree of civilisation while the Hebrews were yet leading a nomadic life.

Their chief industries were the fabrication of silk, porcelain ware, and implements in bronze and iron.* There is good evidence that China had commercial relations with ancient India, the traffic being overland by way of Malacca. It is certain that the Chinese traded with Ceylon and the islands of the Indian Archipelago as early as the sixth century, in the same kind of vessels which they now use. Cosmas mentions the importation of aloes, spices, silk, and sandal-wood from China and other distant regions into Ceylon; that island being at this period the centre of a barter-commerce between the Chinese and the Western nations.

* From a very early period this nation has been in the possession of the art of enamelling metals, and of painting on enamelled surfaces. Our knowledge of the metallurgy of zinc is derived from them.

CHAPTER III.

The Useful Arts as Known to the Classic Nations.

SECTION I.—GRECIAN CIVILISATION.

Agriculture and Allied Arts—Architecture and Sculpture: Houses and Furniture: Pottery—Arts relating to Textile Fabrics and Articles of Clothing and Adornment—Arts relating to Metals: Bronze, Brass, Tin, Iron, Arms, &c.—Intellectual Arts: Letters, Music, Science.

It is to Greece especially that much of our industrial as well as our intellectual life is traceable. Greek architecture, sculpture, poetry, history, and philosophy furnished a basis on which most subsequent efforts have been modelled. We begin with

Agriculture and its Allied Arts.

The Greeks probably received lessons in agriculture from the Egyptians, the Pelasgi having been civilised by Egyptian colonists. Hesiod, who cultivated a farm at the foot of Mount Helicon, in Bœotia, describes the plough of his time as being composed of three principal parts—the share-beam of oak, and the draught-pole and plough-tail of elm or bay, all being securely fastened with nails and pegs.

In the time of Homer bread formed a staple article of food among the ancient Greeks. It was prepared by the women and female slaves. But we are only generally informed as to the means employed. At first the dough was baked between hot stones under a cover of ashes. Afterwards, however, ovens were used, which were also known in very early times to the Egyptians, Israelites, Phœnicians, and throughout Asia Minor.

The bread was made into flat, plate-like cakes, and kept in baskets. It was used instead of spoons to convey food to the mouth, and answered, besides, the same purpose as the modern table-napkin. The Greeks were pre-eminently food-bakers. The bread of Athens and Megara was famous for its whiteness and good taste, and the Athenians are said to have had seventy-two varieties, made of a mixture of milk, honey, oil, cheese, and wine with the best flour.

Wheat, barley, the olive, and the vine were especially cultivated, bread and wine being the staples. Their wines, made from the juice of the grape, were very celebrated; and although the people, as a rule, were not much addicted to beer, yet Aristotle speaks of drunkenness as produced by a beverage made from barley. Sophocles, too, alludes to an intoxicating liquor which was procured from a similar source. It would thus appear that the art of brewing was not wholly unknown.

The breeding of cattle was an important branch of their husbandry. Large herds constituted the sole riches of princes. In the time of Homer flesh was eaten; for the poet tells us that a royal culinary artist placed joints of bullocks, sheep, and goats, roasted, before Ajax and his companions. There were no butchers in those days; princes and heroes killed their own meat, and Homer and Virgil do not hesitate to celebrate the dexterity displayed in this respect.

In Greece, during the heroic ages, an ox was awarded to the victorious pugilist or wrestler; and the Athenians stamped their coinage with its image. The fattening of cattle and the salting of pork were practised among the Greeks. Fattened hogs of five years old are mentioned by Homer. In much later times, when the great towns of Greece arose, the demand for animal food made the butcher's art a regular profession.

Gardens were cultivated by the ancient Greeks. In the

"Odyssey" a minute description is given us of the gardens of Alcinous and Laertes, which produced flowers and fruits all the year round. We read also in Aristophanes, that Athens had its flower-markets and its florists, who wove the crowns worn on festive occasions and the wreaths with which the altars of the gods were decorated. Violets, roses, stocks, the narcissus, and the blossoms of the pomegranate were especially esteemed.

Architecture and Sculpture.

It has already been stated that Greece derived the first principles of architecture from Assyria and Egypt; yet it was a development rather than an adaptation or an invention. There is no question that the peculiar beauty, the simplicity, and the life and power so preeminent, were entirely the result of the exquisite fancy of the Greek mind. We are able to trace the growth of three distinct orders of architecture, the Doric, the Ionic, and the Corinthian, each characteristic of a different period. The Doric, the oldest, is marked by simple grandeur, dignity, and beauty; the Ionic is more graceful, soft, and flowing; the Corinthian, the product of later years, is a magnificent combination of both, but it heralds the decline of artistic feeling.

The exquisite profiles of the Greek mouldings are true conic sections, the properties of which were well understood by the Greeks. The very curious dome-shaped building at Mycenæ affords valuable evidence as to the knowledge possessed by its builders, of the principles of dome-vaulting. The inside of the building forms a pointed dome of forty-eight feet diameter, and of about the same height. The general absence of the arch in Grecian architecture is only due to the circumstance that its form did not harmonise with the horizontal features of their columnar style of building. The Parthenon attests the very complete methods of setting out and executing work employed by

the Greek architects, and its perfection it would be impossible to excel and difficult to equal, even at the present day.

Although the dwelling-houses of the Greeks were small and insignificant, their theatres, gymnasia, and other public buildings were conspicuous for their size, splendour, and proportions. In the fifth century before Christ—a most flourishing time in the history of the Greek states—large sums were expended in the erection of public edifices, and, at Athens, Pericles in particular spent immense revenues. Chief among the architects were Ictinus and Callicrates, architects of the Parthenon, Mnesicles, of the Propylæa, and Phidias, still more renowned as a sculptor. The temples were all more or less adorned with reliefs and statues by the best sculptors, amongst whom Phidias and Polycletus in the fifth century, and Scopas, Praxiteles and Lysippus in the fourth, held the foremost rank. These memorials are such perfect ideals of beauty, and so true to life that the marble itself almost seems to breathe. The statue of the Olympian Jove, the work of Phidias, was so colossal in size that the Greeks were accustomed to say "it would have peeled off the roof of the temple like a thin shell, could it have arisen from its golden pedestal." The masterpieces of Greek sculpture were executed in bronze, in rich white marble, the product of Attica, or of the islands of the Archipelago, and in gold and ivory, statues of this latter sort being called *chryselephantine.* The quarries of the mountains of Pentelicus, near Athens, supplied the most beautiful blocks, from 10 to 15 feet long and 6 to 7 feet thick, some of which weighed 400cwt.: thence were furnished materials for the construction of the Parthenon and the temple of Theseus, and for the temples of Demeter and Persephone in Eleusis. The blocks were obtained by cutting the sides of the mountain into vertical cliffs, at the bottom of which some still remain, partly cut into form for the shafts of columns. The quarries were wrought by slaves, who were sent to work there as a

punishment. For ordinary purposes of architecture, the Greeks used a greenish-white stone, which was everywhere abundant. In Athens, the overseer or wall-maker was a public officer, entrusted with the management of the town wall-work.

Houses and Furniture.—A Greek house was ordinarily built in a rectangular form, the length being double the breadth, and divided into two parts. The portion adjoining the street was occupied by men, and the one behind by women. The interior consisted of a court containing a row of columns, from which entrances led into the various apartments. An upper storey was not usual, the roof being flat; but the walls of the temples frequently terminated in gables with slanting roofs. In addition to private houses, there were establishments for merchants and strangers in the ports of Athens and Corinth; and at the great festivals of Delos, Olympia, and Delphi, where annual markets were held, food and shelter were provided at the public cost. There were also houses of resort for slaves and common people.

Greek furniture was plain and simple. The woods generally used by the cabinet-makers were maple, ash, pear, box, olive, vine, and cypress. Of foreign sorts, there were cedar and ebony. The more costly were cut into veneers, exceedingly thin, and with these the inferior kinds were covered. Besides the usual pieces of domestic furniture, such as chairs, sofas, chests for clothing, and tables with ornamental pedestals, the women had small boxes ornamented with inlaid work, reliefs in ivory, and valuable jewellery.

Locks and keys are referred to by Homer. Pliny ascribes the invention of keys to Theodorus of Samos about 730 B.C. The Greek or Laconic key possessed three wards, and receives its name from being of Spartan invention or manufacture.

Turning.—We first meet with turning among the Greeks,

who ascribed its invention to Dædalus. Indeed, almost every kind of artificer was called a turner. They knew how to soften ivory, so as to form it into plates from twelve to twenty inches broad, and with this they covered their statues. Phidias, an ivory-worker of this description, was thus able to produce his colossal images of Athenē and Jupiter Olympus, considered among the best specimens of Greek art. He is also renowned as having well understood the system of turning in wood. Chariots were often overlaid with ivory, which was also worked into small objects, such as statuettes and little boxes. Greek artificers were particularly expert in cutting figures on signets and gems; and in order to effect this on such stones as agate, carnelian, chalcedony, and amethyst, they made use of the wheel and the style. Pyrgoteles was so celebrated that Alexander employed him to cut his signet. Cameos of the finest art and purest taste are still preserved, affording striking evidences of the skill and delicacy of the Greek workman.

Pottery.—Greece was rich in plastic clay of excellent quality, and from this substance potters moulded vessels of the most artistic and ingenious designs. In Athens a portion of the city was called Ceramicus, by reason of its having been originally devoted to this species of production.

This art formed an important branch both of home and foreign industry, particularly in Ægina, Samos, Cnidus, and Corinth. These places abounded with clay of a red colour, having the requisite degree of plasticity, and capable of resisting fire. Various colours were imparted to it by an admixture with manganese, ferric oxide, blue and green cupric oxides, yellow-ochre, fine pipe-clay, and other earths. The clay vessels were moulded upon a turning-wheel, and afterwards provided with elegant handles, and painted. Some of them were made for household purposes, such as kitchen-utensils, lamps, candlesticks, saucers, plates, jugs, pots, and children's toys, whilst others were decorative ornaments, as vases, jars, and the smaller

vessels used at banquets. Ornamental pottery was an article of traffic to all the countries on the Mediterranean, and was made with peculiar and extraordinary care. Large earthen pitchers—water vases (*hydriæ*) with three handles, and amphoræ with two—supplied the place of wooden casks. Among the remains of Greek pottery are gigantic amphoræ of very coarse grain, measuring eight feet in length and three feet in diameter, and of corresponding thickness. The tub of Diogenes was probably a vessel of this description.

The manufacture of terra-cotta attained to great perfection in the hands of the Greeks. There are no Egyptian works comparable with the grand Greek vases, the best of which were probably made in the time of Phidias. The style of ornamentation is very much alike in all: namely, a few narrow lines or fillets, with dots, flowers, meander fretwork, laurel, ivy leaf, and honeysuckle borders, adorning the rim, neck, and stand of the vases, while the circumference or body is covered with allegorical and other representations. The allegories are chiefly mythological. It is probable that the Greek works were made, some of clay only, some of clay and sand, and others of clay mixed with potsherd and pozzuolano, or other detritus of lava. Pozzuolano, as a material for compounding cements, was well known to the ancient Greeks and Romans, and much used in making pavements.

The black glaze, or rather paint, upon the amphoræ, &c., is a bituminous substance, and that on the vases which have been found in Magna Græcia is a vitreous compound. Terra-cotta vases, amphoræ, and pateræ are found throughout Greece, in Italy, the Hellenic colonies, and Sicily, and would appear to have been a favourite architectural ornament. These articles were, doubtless, in numerous cases, made by hand on a potter's wheel; but many were moulded only. Specimens of Greek glass that have been discovered show the progress of the manufacture after the acquisition of the art from the Egyptians; but we will notice this industry in our remarks upon the glass-making of the Romans.

Arts relating to Textile Fabrics and Articles of Clothing and Adornment.

Spinning and Weaving.—Greek clothing was of great simplicity. The men's garments were entirely woollen, linen being worn by women only. The only decoration was embroidered or figured hems to their robes. A modest Greek woman would have felt dishonoured in a coloured dress. The yarn prepared from Achaian flax was so fine, and the skill of the workers so great, that the fabric was estimated at its weight in gold.

Cotton and silk were introduced from Persia. Previous to the conquests of Alexander these fibres were unknown in Europe. The designation of weaver was not strictly used by the Greeks; the simpler terms of wool-workers and fullers were current. The prevalence and perfection of spinning and weaving are, nevertheless, undoubted. The spindle or the loom was the emblem of woman, as the sword was of man. Princesses and slaves alike practised the art. According to Homer, Helen, wife of Menelaus, even while solemnising the marriage of her daughter Hermione, would not suffer her attendants to intermit their labour. The shawls and the textile furniture used in the rites of religion were frequently woven in the temples. Thus, at Olympia, a new shawl was displayed, which was afterwards preserved in the temple of Herē. The textile art, both as a household employment and as a distinct trade, was under the protection of Athenē, the patroness of industry and of female modesty. The Greeks understood the method of "mounting" the loom, so that, by different arrangements of the warp, a diversity of patterns was produced. Coloured stripes, sprigs, and a variety of simple patterns were thus introduced. The weft or tram was sometimes of gold, of beaver-fur, or of purple wool.

While treating of fibres, we must here briefly make mention of the art of

The Rope-maker.—As ropes and cables are indispensable in navigation, ancient maritime nations, notably the Phœnicians and Carthaginians, must have possessed good cordage. Various kinds were used by the Greeks and Romans. Hemp was introduced into the ports of ancient Greece expressly for ships, and Hiero of Syracuse received large quantities of it from Gaul for the manufacture of cables. Although little mention is made of the rope-maker's craft, it was undoubtedly an important occupation. Ropes were used in the gymnasium by the ancient Greeks. Among their games was one called the *Scapenda.* A pillar was erected with a hole in it, through which a rope was passed; two men held each an end, and the man who succeeded in pulling his antagonist up to the pillar was declared to be the victor.

Leather-dressing.—Homer clothes his heroes in lion and leopard skins, worn over their armour, and mentions Tychius by name, as the currier who made the shield of Ajax Telamon of sevenfold ox-hide. The Greeks acknowledged that their progenitors wore skins, and the shepherds of the mountains were thus dressed down to a late date. Although furs were not common, yet of leather so many useful articles were manufactured, as to make it a special industry. Cleon of Athens is specially named as the principal leather-dresser of his time. The main source of supply was Attica, but skins were also brought from Cyrene and Sicily. The most common articles of leather were sandals, shoes, aprons, helmets, and shields.

Helmets made of metal or leather were worn in battle, with a kind of visor or iron band capable of being drawn up and down to protect the face and temples, and long enough in the hinder part to protect the neck. They fitted close to the cranium, like skull-caps, and were sometimes ornamented with plumes. An elaborate band passed under

the chin, to adjust the helmet comfortably. Homer describes the helmet of Achilles in such terms as to give us the impression of the splendour which it assumed upon the brow of the ancient hero :—

> "Like the red star, that from his flaming hair
> Shakes down diseases, pestilence, and war,
> So streamed the golden honours from his head,
> Trembled the sparkling plumes, and the loose glories shed."
>
> POPE.

Greek Shoemakers.—The shoemaker's craft was of some importance amongst the Greeks. Pythagoras required his disciples to wear shoes made of bark, in order to avoid the use of skins which once had life. It is also stated of Pericles and Socrates that they often went to the workshop of a shoemaker called Simon, for the purpose of discussing political and philosophical questions. Socrates, whose disregard for heat or cold was remarkable, did not, however, wear the boots made by his disputant, for, like many others, he usually walked barefooted. Boots and shoes, as well as sandals, were used by the Greeks. The shoes were doubtless developed from sandals, by the substitution of upper leathers for strap fastenings; and the extension of the upper-leathers beyond the ankles, and sometimes half-way between the ankle and the knee, constituted boots. Greek women were in the habit of richly decorating their boots with ornaments fastened round the ankle; and, according to Plato, the young Athenians were particular about the elegance and style of their feet-gear.

Grecian Costume.—The Greeks enjoyed so genial a climate that a covering for the head was rendered unnecessary; except, therefore, when travelling, they went bareheaded. The husbandmen, however, who were more exposed than others to the vicissitudes of the weather, adopted some sort of cap. The *Petalus* and the *Kàusia,*

according to Dr. Rehlen, were the two forms of hat most used in journeys. The first consisted of a crown, which was arched, and a broad brim, bending downwards and tied under the chin, as seen in the statues of Mercury; the second was a mere cone, with a flat or horizontal brim, and is to be seen sculptured in the Elgin marbles. Its popularity extended through Asia, and lasted even till the time of Charlemagne.

In Greece the hair was regarded with pride by both sexes. The marble busts of the philosophers look venerable, from their dignified and carefully-dressed beards. The colour of the hair was usually dark—either black or brown; but fair hair was not unknown, for the Achaians are described by Homer as possessing it.

The Dorians, of whom the Spartans were the most eminent, made their locks perform a prominent service as part of festive attire, decorating them and wearing them long on all occasions of rejoicing. In Athens the advance from youth to manhood was recognised by a religious ordinance; the hair was solemnly cut off, and laid as a votive offering upon one of the sacred altars. Its management in after life became an art, and much of the consideration a citizen received depended upon the care bestowed upon it, which was regarded as a sign of good-breeding. The practice of shaving the chin was commenced in the days of Alexander the Great, B.C. 330, who ordered the Macedonians to be shaved, lest their beards should give a handle to their enemies. The Greek women wore their hair in various ways, but the mode most generally favoured was that of a spiral tuft, made by twisting the back tresses into a queue, fastened with a comb or hair-pin in a mass on the top of the head. Another and a simple fashion allowed the hair to wave across the forehead to the temples, and thence fall behind in ringlets. The pins were made of gold or bronze, and the combs used were often choice and costly. The head of the pin was large and ornamental;

serving for part of the head-dress. In all these fashions art was made subservient to nature.

There was but little employment for the tailor or dress-maker, most of the fabrics of the loom being worn as scarfs or shawls, arranged in loose folds about the person. Custom or rank had much more influence on the material than on the form of the dress. The main characteristics of Greek costume were its ease and freedom.

Dyeing was but little regarded, the natural colour of the wool being thought by both sexes to be alone becoming. The nearest approach to variegated attire was the upper loose garment, which was occasionally worn figured or striped, especially at festivals.

Arts Relating to Metals.

1. *Bronze.*—In all the Grecian states and colonies there were superior workers in bronze, which was used for much the same purposes as iron is now. Compounded of copper and tin, the bronze was made hard or soft according to the end it was intended to serve, and was rendered capable of bearing a sharp edge, for employment either as artificers' tools or as weapons of war. The use of bronze in Greece, as among the nations already referred to, appears to have been carried to an almost incredible extent. Armour and helmets, swords and lances, bracelets and chains, hair-pins, rings set with jewels, stools, tables and bedsteads, candelabra and statues were all made of it. The Colossus of Rhodes was one of the Seven Wonders of the World; and Corinth was so full of bronze statues that at the taking of the city by the Romans the molten metal is said to have poured down the streets, and to have originated the compound known as Corinthian brass—two-thirds copper and one-third silver. Pliny says that in the reign of Alexander the Great, bronze statues were perfected under the guidance of the artist Lysippus, who improved the modes of moulding and casting. Athens was decorated with about 3,000 bronze statues.

Rhodes, besides its lighthouse and bronze tower, had as large a number; and at Olympia and Delphi they appear to have been no less numerous.

2. *Brass.*—Brass, which is a compound of copper and zinc, is easily cast, ductile and malleable; and its great utility has made the art of the brazier important from very early ages. Ancient brass differed in manufacture from that of the moderns, inasmuch as the method of extracting zinc from its ores has only been practised since the beginning of the eighteenth century, before which date the ore of copper containing spelter or calamine (the ore of zinc) was alone employed for brass. Bronze, an alloy of copper and tin, as stated in Chapter I., has often been erroneously called brass. Brass-founding was skilfully but not extensively pursued by the Egyptians, who cast statues of excellent execution. The Greeks, however, carried it to great perfection, and objects of art in this material were valued almost as highly as those made of the precious metals. There were various kinds of brass, all of which were so esteemed in Persia and India that Aristotle thought the brazen vessels of Darius, which closely resembled gold, worthy of special description. In the zenith of Grecian art, brass statues, candelabra, vases, and household ornaments were to be found in every home of taste. Statuettes were made in one piece, but larger objects were cast in parts, which were modelled in wax with a coating of calcareous plaster, the wax being afterwards dissolved by heat for the introduction of the metal. Greek artists, such as Theodorus of Samos, who lived about six centuries before the Christian era, Phidias, and Polycletus, mentioned above, have left historical names for their great skill. Phidias produced a brazen statue of Athenē Promachus* nearly 60 feet high, for the Acropolis of Athens. Lysippus in fertility exceeded even these, for,

* A distinction is necessary here. Phidias executed two statues of Athenē for the Acropolis, (1) the Athenē of the Parthenon, which was chryselephantine, (2) the Athenē Promachus (defender) of brass or bronze.

besides his famous statues of Alexander the Great, he left "to breathe in the brass of Lysippus" 1,500 other works. Roman brass-working was entirely in Greek hands, and was of the most extensive character. Numerous statues raised in Rome, such as that of Nero, 110 feet high, and of Domitian, with the bronze equestrian statue of Marcus Aurelius in the Capitol, are still extant.

4. *Iron.*—Iron first came into common use in Greece. Homer, in speaking of it, declares that with it were made poleaxes, shipwrights' tools, ploughshares, sheep-hooks, and chariot axles. Our modern word "chalybeate" is derived from Chalybes, a term used loosely to designate the tribes of the Black Sea, whose land was "the mother of iron and of the sword."

The ancient mode of reducing the ore was rude and slow, the crude mineral being pounded by hand in a mortar, and the earthy particles afterwards washed away from the metallic granules. Some such primitive process prevails in parts of Catalonia even now, having existed possibly for a period of more than 2,000 years.

Ancient writings are rich in the description of arms and armour. The description of Goliath is of interest, apart from its Scriptural character, in the perfect picture it presents of the accoutrements of a soldier. Homer describes the golden armour of Glaucus as worth a hundred oxen. The shield of Achilles was elaborately adorned. In the account given of Agamemnon, the whole suit of armour is described :—

> "And first he cased his manly legs around
> In shining greaves, with silver buckles bound ;
> The beaming cuirass next adorned his breast.
>
> * * * *
>
> Ten rows of azure steel the work enfold,
> Twice ten of tin, and twelve of ductile gold ;
> Last o'er his brows his fourfold helm he placed,
> With nodding horsehair formidably graced."
>
> POPE.

Homer's description would require to be but slightly modified for the Greek soldiers at Marathon, Thermopylæ, and Platæa.

In fashion, as well as material, the Greek and Roman weapons resembled those of Egypt, except that the sword was shorter and broader. It is difficult, with our modern ideas of sharp steel swords, to believe that the conquering legions of old chiefly wielded weapons of brass. Of Agamemnon's sword it is said—

> "A radiant baldrick o'er his shoulder tied,
> Sustained the sword that glittered at his side;
> Gold was the hilt, a silver sheath encased
> The shining blade, and golden hangers graced."
>
> POPE.

Diodorus and Plutarch have thus described the ancient steel sword manufacture: "The iron is buried in the ground, and left till it is almost wholly rusted. What remains is forged, the sabres made from it being so beautifully tempered that they will cut through bones and helmets or sever a nail without spoiling the edge."

INTELLECTUAL ARTS.

Letters.—The Greeks, in all probability, derived their knowledge of the letters from the Phœnicians, who belonged to the Semitic family of nations. They were early acquainted with the use of papyrus, which is mentioned by Homer, Æschylus, and Herodotus. Anterior to the fifth century before Christ, however, not only the use of the papyrus, but even the practice of writing was very uncommon. The introduction into Greece of papyrus from Egypt, previously to which the bark and leaves of trees, linen, lead, and wax were used as writing materials, produced great results in increasing the diffusion of writing, and in making books better known.

Parchment was brought into use by Eumenes, King of

Pergamos, and a patron of learning, as a substitute for papyrus, the exportation of which from Egypt was prohibited by Ptolemy Philadelphus (B.C. 263), to prevent Eumenes from increasing his libraries. This material had previously been used, but, on account of its brittleness, was not in favour. Eumenes, however, so improved the process of its preparation that he may be almost termed the inventor of parchment. Its introduction eventually led to the present form of books.

Books were first collected by Polycrates and Pisistratus; and after the conquest of Egypt by Alexander the Great, the famous library of Greek and Egyptian papyri, or papyrus rolls, which we have before mentioned, was established at Alexandria.

Music.—The music of the ancient Greeks was from the earliest times bound up with their religious institutions. It differed, however, from that of the early Egyptians, by being always associated with poetry, to the effective delivery of which music seemed essential. The Greeks seldom separated poetry from melody; the poet usually composed his own music, and sang his own strains at the public games. The song was what we may now call a recitative; the number of musical notes was scanty, and "air" or "tune" somewhat wanting. Such, too, is still the method adopted by the *improvisatori*, or Italian extempore poets, who deliver in recitative a series of impromptu verses with such energy and volubility as to excite the surprise and attention of those around them.

The tragedies of Æschylus, Sophocles, and Euripides were in their mode of performance not unlike modern operas. They were delivered chantingly, so to speak, and were generally accompanied by a flute or a lyre. The flute was the companion of elegiac poetry, the lyre of the epic and of the ode. Greek music appears to have been in general only a kind of rhythm, or accurate measurement of musical time; counterpoint, the origin of which is referable

to a more advanced period, was not understood. The ancient flute was not the elegant instrument, made of hard wood and ivory, which modern art produces, but only a metal tube, or oftener the reed pipe of the *Calamus agrestis*. The lyre, the form of which is well known, was held between the knees in playing: it had originally four strings, then seven, afterwards eleven. The harp was partly played with the fingers, and partly with the *plectrum*, a small stick or quill. Professional flute-players among the Greeks were in great favour and demand, and obtained extravagant sums for their services in the temple or theatre. Solo performers were appreciated in proportion to the noise which they made, and historians tell us that in their contests at the public games Greek trumpeters thought themselves fortunate if they escaped without rupturing a blood-vessel through the violence of their exertions. The cultivation of lyric poetry gave an impulse to music. Schools were founded in which instrumental playing was taught, and greater skill was attained in the art.

From that time appeared masters who gained for themselves great renown by their powers of execution. The names of several players are recorded, among whom were Antigenidas of Thebes, and Damon, who taught Pericles and Socrates the use of the flute. Pythagoras greatly improved music by his experiments and calculations, and is said to have added an eighth string to the lyre.

Science.—We are indebted to the Greeks more than to any other ancient nation for the advance of astronomy. Thales and Pythagoras brought mathematics from Egypt into Greece, where the science was still further cultivated. Thales was taught astronomy, geometry, and philosophy, under the priests of Memphis. The numerous astronomical observations made by the Greek philosophers show that their instruments must have been in a tolerably perfect condition.

Dicearchus made brass instruments for measuring altitudes

in the Peloponnesus. Anaximander, an Ionian philosopher and disciple of Thales, is said to have prepared celestial globes, and to have introduced sun-dials into Greece. Eudoxus, of Cnidus, established an observatory, and is said to have acquired his knowledge of astronomy in Egypt, where he spent thirteen years in study, under the direction of the priests.

Hesiod and Homer mention several of the constellations. Democritus, a Greek, taught that the Milky Way was caused by the light from innumerable stars. Aristarchus of Samos recognised its immense distance; and not only guessed at the earth's annual motion in its orbit around the sun, but also at its diurnal rotation on its axis. Eratosthenes placed in the museum of Alexandria an armillary sphere, fixed upon rings, on which the ecliptic, the equator, and the colures were represented. It was Pythagoras, however, who taught the true system of astronomy; the world, nevertheless, was not prepared to receive his views, which lay neglected for nearly 2,000 years. Posidonius of Apamea estimated the distance of the sun and moon, computed the height of the atmosphere, and attempted to measure the earth's circumference. But Hipparchus (B.C. 150) was the most renowned of the ancient astronomers of Greece. He not only held the same views as Pythagoras, but was acquainted with the acceleration of falling bodies, although without comprehending the cause. He discovered the precession of the equinoxes, which causes the slow apparent motion of the fixed stars from east to west, invented several astronomical instruments, by means of which he noted the apparent magnitudes and places of the heavenly bodies, and formed a catalogue of all the constellations then known, so that, if any changes should take place in the aspect of the heavens, future generations might be able to detect them. Delambre says, "Hipparchus seems to be the author of every great step in ancient astronomy."

Euclid, of Alexandria (B.C. 300), gave to mathematics a

scientific foundation; and Sicily enjoys the honour of having given birth to Archimedes, the first philosopher who may be truly called a scientific mechanician. The siege of Syracuse by the Romans was greatly protracted through the destructive engines invented by him. No precise account is given us of the machinery employed by him in lifting up and destroying the galleys of the enemy, and most probably the effects were exaggerated. The victorious general, however, was so impressed with the genius of the man who could construct such engines that he issued orders to his soldiery merely to take Archimedes prisoner, and bring him alive into the Roman camp. Unfortunately for science, the Roman soldiers did not know him. One of them, on entering his presence, found him wholly occupied with a mathematical problem, being perfectly unconscious that the city had been taken. On being interrupted he said, calmly, "Stay, soldier, do not spoil my diagram." He was, however, immediately struck by a blow which proved fatal. The first explanation of the lever was given by Archimedes, and in so popular and, at the same time, scientific a manner that it has never been surpassed. Levels, circles, surveying-poles, scales, protractors, astrolabes, and quadrants were all known to the Greek mechanicians; but as there was still an absence of optical instruments, observations could only be made with the unassisted eye. There were indeed burning-mirrors in the time of Socrates, but these and the reflectors with which Archimedes is said to have set fire to the Roman fleet, must have been made of metal.

SECTION II.—ROMAN CIVILISATION.

Agriculture and Allied Arts : Meat-markets.—Architecture, Public and Domestic : Inns, Pottery, Glass.—Arts relating to Clothing and Adornment : Greek and Roman Jewellery.—Arts relating to Metals: Iron and Bronze, Iron-smelting, Lead-smelting, Arms, &c.—Intellectual Arts : Literature, Music.

The Romans followed in the footsteps of the Greeks in the cultivation of the arts and sciences, although not with the same energy, and originality. To facilitate communication between all parts of their extensive empire, they constructed roads which have been the admiration of the world. They also erected buildings which are unequalled for grandeur. The palaces of the rich and great contained libraries filled with rolls of papyrus, the most exquisite sculpture, and everything that could contribute to the most refined enjoyments of life ; but of these treasures we may perhaps say that the Romans were rather the collectors than the producers.

Agriculture and Allied Arts.

Agriculture was considered by the Romans a most important and profitable occupation. They practised irrigation and drainage ; and, besides the usual cereals, the grape was much cultivated, with an extensive variety of garden produce. In their hands the plough was much improved, and they possessed a great variety of implements, which were little inferior to those of modern times. Despite this, there is not much reason for supposing that the Romans were ever very greatly advanced in agriculture. Slavery has among all nations retarded progress, whilst the establishment of freedom of thought and action has at all times ameliorated the agricultural as well as all the other arts of life. Hallam says :—" In the agricultural economy of Rome, the labouring husbandman, a menial slave,

had not even that qualified interest in the soil which the tenure of villeinage afforded to the peasant of feudal ages."

The ancient Britons were taught agriculture by the Romans, by whom the plough was introduced among them. During the four centuries of the Roman occupation of our island, they introduced from their other possessions all the methods and appliances of agriculture which could be adapted to its climate. Tacitus writes of the Britons that they complained of being forced to the labour of clearing woods and draining marshes. These operations imply that endeavours were made by the Romans to bring waste lands under cultivation; their success in this direction is indicated by the fact of an increased exportation of corn to the granaries of Rome.

Among the Romans the grain was either trodden out by cattle or beaten out with a flail, and appears to have been separated from the chaff by winnowing, or by exposure to the wind. For a long time they roasted their corn and pounded it in mortars, as they had no better method of procuring flour. They applied the name of *pistores* or grinders to the slaves who bruised the material. The Romans derived their knowledge of the hand-mill from the Greeks. These primitive mills were turned by women or slaves, who were obliged to deliver a certain quantity of flour before leaving the task imposed upon them. The hand-mill, or quern, is still to be met with in the Highlands of Scotland, and at the doors of old English castles. It is figured on the columns of Trajan, as part of the camp equipage of a Roman soldier.

The cattle-mill was the next advance; the difference in the construction was that a shaft was added to the upper stone, in order that the labour of animals might be substituted for that of man. If a slave offended his master, he was frequently sent to the cattle-mill, where he received the name of the animal whose post he occupied, hence the

epithet Asinus! * Plautus, it is said, wrote some of his comedies during the short intervals allowed for rest from his labours of grinding.

Water-mills were known in the time of Augustus, for both Vitruvius and Strabo mention them. They were, nevertheless, not used in Rome until the reign of Honorius and Arcadius, in the fifth century.

Unleavened or unfermented bread was undoubtedly the first used; the flour, simply moistened with water, so as to form dough, was made into cakes, and then baked. Bread thus manufactured was necessarily heavy and indigestible. It is not known by whom leaven was first used; it was, however, a great discovery, and has benefited mankind in a most practical manner. At first the only leaven employed was the dough itself, which was kept until it became thin, sour, or partially fermented. The next process was the kneading of this with the flour, which in time produced fermentation throughout the entire mass. Pliny informs us that the Romans learned the use of leaven from the Greeks, during their war with Perseus, King of Macedon; and in their turn they communicated the knowledge of it to the conquered nations of the North of Europe. The ordinary sea-biscuit of sailors is merely unleavened bread, without salt, and is largely used from its power of resisting the influence of the moisture contained in the air. It is the *panis nauticus* of the Romans.

The Roman loaf was similar in size and shape to that of the Greeks. There were several kinds, made of wheat, barley, and spice. The wealthy Romans usually had prepared for them round loaves of the very best flour, and of uniform weight. A heavy, coarse, dark-coloured biscuit, composed of bran mixed with a little flour, was the food of slaves and dogs. The bread of the athletes was kneaded without leaven, with soft, white, curd-cheese, a coarse heavy food, much relished, however, by that class. Slaves who could make good bread were highly valued.

* *Asinus* was also Latin for the nether grindstone.

There were 329 public bakeries in Rome in the reign of Augustus. Millers and bakers were incorporated under the Emperor Trajan (A.D. 98—117). The corn was supplied from the public granaries by the magistrate, in return for which the public were to be furnished with a sufficient quantity of good, wholesome bread.

Gardening.—The art of gardening was carried to great perfection by the Romans, whose cultivated grounds were enriched with the fruit-trees and floral treasures of the numerous countries under their sway. The gardens of Lucullus, at Baiæ, on the Bay of Naples, are justly celebrated, as containing all the plants of any value then known in the East, such as the cherry, the peach, and the apricot. Mention is also made of the gardens belonging to Sallust, Nero, and Hadrian. Pliny the Younger had one also on his Tuscan estate; the beds, he tells us, were bordered with box-trees and acanthus, beds of roses, reservoirs of water, and winding promenades. The Floralia which were annually held in Rome during the last four days of April show that the love of flowers was a popular sentiment. In addition to ornamental plants, the grape was extensively cultivated, and we learn that cucumbers were grown all the year round by the Emperor Tiberius (A.D. 14). Paintings have been rescued from the ruins of Herculaneum and Pompeii, which give us a good idea of the Roman gardens. They are represented as square plots of ground in front of the house, enclosed with trellis-work, and ornamented with fountains, urns, and other architectural embellishments. Plants, both in boxes and pots, are in the garden walks and in the windows, and vines resembling the honeysuckle are trained to climb over the doors of the houses. According to Diodorus and Suetonius, the kitchen-gardens of the Romans contained many of the vegetables now in common use. The carrot was cultivated at an early epoch, and the turnip occupied the same place as it does now in British husbandry.

Parsley was reared as a pot-herb, and was known also to the Greeks. Pliny tells us that parsnips were grown on the banks of the Rhine, and when dug up were brought to supply the rich tables of the luxurious Roman emperors.

The Romans planted trees for shade and ornament, and cultivated beds of osier-willow for the purpose of basket-making. We have no record, however, of trees being planted simply for the sake of their timber, as is the present custom in England and different parts of Europe. Wood in these times was of course abundant, and when wanted was procured from natural forests.

Meat-markets.—The Romans were great consumers of animal food. Corporations were established in Rome, composed of selected citizens, who furnished the city with the necessary number of cattle, and superintended the slaughter-houses and the sale of meat in the public markets. In choosing cattle, the judges preferred those of a dark colour, inasmuch as they believed that the flesh was more solid and nutritious. Under the Roman emperors, splendid slaughter-houses were built of marble; and Nero erected at Rome a meat-market equal in size to the amphitheatre. Sausages, strongly spiced, and prepared in small tin ovens, were exposed for sale; and passages in the writings of Plautus prove that beef, veal, and pork were sold in the public markets.

Dogs were eaten by the common people, especially at the annual celebration of the deliverance of Rome from the Gauls. It is a tradition that the Gauls scaled the walls of ancient Rome whilst the dogs slept, and that the city would have been taken but for the cackling of some geese, which aroused the garrison. On this day especially, according to Plutarch, the people regaled themselves with boiled and roasted dog; but by the wealthy Romans such diet was held in utter contempt.

At the time when the Roman dominion was most widely extended and flourishing, the greatest variety of

animal food was sent to Rome from different countries and climates. Luxury was then at its height. Sometimes only a very small portion of the animal was eaten, such as the brains or tongue. One dish, however, above all others, was very much esteemed. It consisted of an entire pig, the stuffing of which was composed of smaller animals, poultry, and other kinds of game. It was called by the Romans the "Trojan Horse."

Both the Greeks and the Romans concentrated their wines, either by spontaneous evaporation, or by boiling. In this way the liquor was reduced to a syrup, or even a solid cake, and could be preserved for many years. The Austrian "*bier stein*," or stone beer, in the Zollverein department of the Exhibition of 1851, prepared from an extract of malt and hops only, and fairly portable, appears to have been a preparation very analogous to the ancient solidified wines.

Architecture, Public and Domestic.

The Roman ideas of architecture were originally derived from the Greeks. The style adopted was the rich Corinthian, which the Romans may almost claim as their own. Their examples are not only more numerous and varied, but are also very different from the original models. As might naturally be expected, a rich and powerful people greatly modified the quiet simplicity and harmony of the ancient type ; they raised it to colossal proportions, increasing at the same time its splendour and magnificence. They were the first to spread the knowledge of the arch, which they learnt from the Etruscans, and employed as a leading principle of construction. The Romans built chiefly with brick, and they probably had not the means of executing the flat massive stone roofs with which the Egyptians covered their halls and porticoes. The extensive use of both burnt and unburnt bricks by the Romans is evidenced in the existing ruins of those materials. They introduced

brick-making into England, where they used large thin bricks or wall-tiles as a bond for their rubble construction. It has been said by one writer that no traces of an acquaintance with the most difficult problems of construction are to be found in their architecture, their mouldings being formed of circular curves only. Nevertheless, the works of the Romans exhibit great practical knowledge, and their vaults and domes were of such spans as would at the present day, with all our science and mechanical appliances, be considered bold undertakings. The dome of the Pantheon at Rome is a hemisphere, 139 feet in diameter, and the groined vaults of the Temple of Peace were upwards of 70 feet span. A characteristic feature of Roman work is, however, an inattention to minute details; their domes and cupolas were constructed upon a simple system of centring, whilst their groined vaults exhibit a departure from the true principles of construction.

From the republican period we may trace the erection of amphitheatres, circuses, triumphal arches, aqueducts, basilicas, baths, mausoleums, and temples. Even in their ruins, some of these are so grand in their proportions as to impress the spectator with an involuntary feeling of awe and admiration. The Coliseum, commenced by Vespasian and finished by Titus, was 560 feet in length, 466 feet in breadth, and 200 feet in height, and capable of accommodating 100,000 spectators. During the empire, numerous splendid and extensive palaces were erected at Rome. The golden residence of Nero occupied a whole district. Rich and noble citizens had also palaces provided with numerous wings, containing sleeping and dressing rooms, banqueting-halls, picture-galleries, libraries, and reception-rooms. The walls, doors, and pillars were of marble, the floor of mosaic work, and the interior court enriched with pillars, statues, and other works of art. Rows of such palaces stood in the Forum, the centre of the city, in the Field of Mars, and in the so-called holy streets. In the reign of

Augustus, Rome is said to have contained 1,500,000 inhabitants and 40,000 houses; its suburbs extended for miles into the country, and were covered with temples and country-seats. Under Aurelian, this enormous city was surrounded by a wall, which was completed by Probus; it had 381 towers, 6,925 parapets, sixteen gates, and seven bridges. Well-constructed roads extended from Rome in all directions to other towns containing similar architectural works.

As a natural consequence of the rapid growth of Rome, and the accumulation of that wealth which enabled its citizens to erect such splendid monuments, the arts of the mason and builder were greatly extended and improved. Slaves were usually employed in the rougher sorts of labour, whilst Greek workmen, architects, and sculptors were engaged by the State for the production of the reliefs, statues, busts, altars, sepulchral tablets, and mosaics. Tenodorus, Menodonus, and Demetrius are mentioned by historians as architects who were pre-eminently skilled in these different branches.

Supplies of building materials—stone, clay, and lime—were obtained from Greece, Asia Minor, and Africa. The tiburtine or travertine stone, a calcareous rock, was much used in the construction of ancient Rome. The building stone was well prepared by the masons and builders, who also possessed great skill in the working of coloured and other kinds of marble. They knew how to make bricks of an enduring quality, to prepare excellent mortar, and to restore to their original colour walls tarnished by time and exposure. After the fall of the Roman Republic, the walls of villas and public edifices, hitherto only simply white-washed, were elaborately painted with scenes from mythology and country life, the pillars of brick and lava were overlaid with stucco, the floors were covered with pictorial representations in mosaic work, and a method was discovered of giving to the humbler buildings the appearance of marble structures.

Domestic Architecture.—The private houses of ordinary people partook of the general improvement and the tendency to luxuriousness. During the earlier periods, when Rome was without that power which she ultimately acquired, the houses of the citizens were but rudely constructed. The walls, built of unburnt brick, were only one storey high, and their wooden roofs were covered with reeds or thatch. During the latter days of the Republic, even up to the time of Augustus, the city possessed only irregularly-built wooden houses; but afterwards, instead of the simple work of the carpenter, the borders, friezes, and doorposts were made of marble, whilst the side-posts, threshold-casements, and the capitals of pillars were richly worked in bronze.

The interior arrangements of Roman dwellings were similar to those of the Greeks, except in the furniture, which was of a more showy and costly description. We learn that the *abaci*, or sideboards, were made of marble and silver, and that splendid vessels were placed upon them; and, as a further example, we may mention that the Roman wine-tables were elaborately carved, and ornamented with valuable metals, bronze, and marble. The top, which was round, and sometimes four feet in diameter, was usually made of African cypress or citron wood; this rested on one fine pillar or pedestal, the feet representing panthers' claws, which indicated it to be a wine-table. There is abundant proof that the art of turning flourished at Rome, in the numerous ornaments which adorned their chairs, tables, bedsteads, sofas, stools, and other articles of domestic furniture.

Roman Inns.—The great numbers of foreigners in Rome, combined with the commercial activity which had there centered itself, necessarily called into existence a number of inns. These resembled modern cookshops and taverns. Pliny tells us that Lucius Mummius was the first in Rome who affixed a picture, clearly a sign, to the outside of his house. On the great Roman roads were to be seen public-

houses with signs and names as at the present day. Some of the signboards of these ancient Roman inns have been disclosed amongst the ruins of Herculaneum and Pompeii. A few of them were painted, but as a rule, they were made either of stone or baked clay, and let into the pilasters or square columns of the house. One of these signs represented two slaves carrying an *amphora*, or Roman pitcher, not unlike the old English sign of the "Two Jolly Brewers." Another sign, evidently belonging to a wine-merchant, was a painting of Bacchus pressing a bunch of grapes. These inns, however, were little worthy of the name, being simply receptacles for the humblest class of travellers. They only afforded food of the coarsest character, and shelter for a single night.

Pottery.—The Romans derived their knowledge of the art of pottery from the Etruscans, whose numerous vases, both of glazed and plain ware, were so beautifully and elegantly formed as to be highly esteemed at a much later period. The production of this ware appears to have continued from B.C. 650 to the fall of the Etruscan power (B.C. 283). The fine plastic Etrurian clay was largely used by the Romans, who displayed great skill and taste in their manner of moulding it into earthenware vessels, such as plates, dishes, bowls, water-bottles, round drinking-flasks, with from one to three handles, small salve and oil flasks, and large wine-pitchers, often from three to four feet in length, together with bowls, lamps and urns for the ashes of the dead.

From the date of the extinction of Greek art in pottery (B.C. 150), *amphoræ* and other articles began to be fashioned in imitation of sculptured works of marble or bronze, with ornament in bas-relief. This class of work has continued more or less from the commencement of the Roman Empire till now. The Roman terra-cottas consist chiefly of cinerary urns, lamps, and *pateræ*; the bodies of these appear to have been moulded, whilst the ornamentation was given by incision or embossing.

Very large quantities of Roman pottery have been discovered in this country, as well as the kilns and tools used by the potter, thus indicating the extent to which the earthenware manufacture was carried on here by the Romans. This British-Roman pottery is of three descriptions—the Upchurch, the Castor, and the Samian. The Upchurch pottery is of a fine and hard texture, and of a blue-black colour, which was produced by baking it in the smoke of vegetable substances. The forms and patterns are very varied. The Castor pottery was of a superior quality, and more elegantly adorned than the Upchurch. The Samian ware, so called from its resemblance to the earthenware made from the red clay of Samos, of which vases, jugs, and basins, with glazed surfaces, were made, is altogether unlike the terra-cotta of Egypt or Greece. Other works of the Romans in pottery consisted of bricks and tiles: the hypocaust tile and earthen *tesseræ*, used in their mosaic pavements, were of durable materials, though coarse and rude.

Pliny tells us that bricks made so light as to swim in water were produced at Marseilles, at Colento in Spain, and at Pittane in Asia. The knowledge of the materials used in fabricating them was completely lost till M. Fabbroni hit upon the discovery.

Glass-making.—The origin of this art, to which we have already had occasion to refer, is entirely unknown. It is not unlikely that the discovery was accidental. Pliny says (Nat. Hist. lib. xxxvi. c. 26) "that certain mariners, having a cargo of natron or soda on board, landed on the banks of the river Belus, a small stream in Palestine. Finding no stones upon which to rest their pots, they placed under them masses of natron, which, together with the sand of the river, being fused by the heat, produced a liquid and transparent stream. Such was the origin of glass."

This tradition of the discovery of glass can scarcely be

received, but we have furnished in previous chapters of this volume evidences that appear to throw the discovery very much further back in time than Pliny puts it. Glass was common amongst the Romans, especially after the republican period, and glass-making is among the few arts that were not disused after the overthrow of Roman civilisation.

The different specimens of glass found at Nîmes, Trêves, London, &c., which are regarded as Roman, are variously coloured, and show that the fabricators were familiar with the processes of moulding, blowing, casting, and flattening.

Roman architects are known to have used glass in their mosaic decorations. In the latter part of the first century glass factories were built; and in the following years the manufacture was brought to great perfection in the production of beads, and such vessels as bottles, goblets, salve-flasks and bowls, cinerary urns, &c. The cinerary urns of green glass have excited great interest, on account of their beauty and skilful workmanship. Mr. Apsley Pellatt writes: "The round vases are of elegant forms, with covers and two double handles, the formation of which must convince any one capable of appreciating the difficulties which even the modern glass-maker would have to surmount in executing similar handles, that the ancients were well acquainted with the art of making round glass vessels." Glass is said to have been employed for admitting light to the houses in Pompeii, and glass windows are known to have been used at the end of the third century. In the fourth century the craft was so much valued that glass-makers were freed from taxation by Constantine the Great.

Arts relating to Clothing and Adornment.

Spinning and Weaving.—Spinning and weaving, chiefly of wool, during the time of the Republic were, as in Greece, the domestic employment of the women. Cotton and silk were used soon after their introduction into

Greece. For a long time silk tissues were excessively dear, and were worn only by ladies of the highest rank, whilst, in the time of the emperors, men who thus robed themselves were satirised for effeminacy. Aurelian, in the year 274, forbade the use of silk, and refused his empress a dress of this material, on account of its costliness. Various substitutes were, however, adopted, both in Rome and in Greece. The island of Cos, in the Ægean, became celebrated for the fabrication of robes of fine transparent gauze, made by unravelling the close silk tissues of Persia and India, and re-weaving the fibres. Pamphylia was the first to spread out these importations into lighter and superior fabrics, which were now worn not only by women but by men. Another material was that named *subsericum*, in which, as the name implies, a part of the stuff—the woof alone—was formed of silk. By the fourth century the cost of silk had so greatly diminished that it was no longer beyond the reach of the middle classes.

Leather-dressers.—Leather was much used for the portable chairs fashionable among the Romans, and for the different sorts of carriages which were first brought into general use in the streets of Rome. In travelling-carriages the leathern trunk also found a place.

The ancient Romans, like the Greeks, wore skins, and also used them for their couches. Curriers and harness-makers are said to have existed as early as the reign of Numa Pompilius. Furs were not common amongst the Romans until the third century of the Christian era, when they were brought into more extensive use by the northern barbarians from Germany. They became afterwards highly-esteemed objects of luxury, costly furs being furnished by Persia as well as by Germany. As to the methods of preparing leather and furs the ancient writers are almost wholly silent.

Shoemakers.—In Rome, as in Greece, sandals were the first form of protection used for the feet. Shoemakers, how-

ever, gathered themselves into an association in that city at an early period. The profuse and voluptuous tastes of the citizens were subsequently shown not only in the soft and delicate leather used in the manufacture, but in the embroidery and the gorgeous ties, which were composed of wrought gold and silver. An ivory crescent was the common ornament adopted, but Caligula enriched his shoes with pearls and jewels. So important was the art that the fashionable shoemakers became very wealthy, and could afford to give to their fellow-citizens public entertainments of swordsmanship. The Roman ladies generally wore white shoes, but occasionally red, scarlet, purple, or yellow. Then, also, as now, small feet were desired, as being most comely and beautiful. Fashion in ladies' shoes was carried to great excess, as many as twenty-two different shapes having been patronised. Extravagance in shoes eventually reached such a point that sumptuary laws were enacted to regulate both the material and the form.

Saddlers.—Horses, apart from chariots, were not much employed in martial encounters until cavalry were first regularly appointed after the Persian war. Saddles, such as are used at the present day, were certainly unknown to the Romans, and it is probable were not invented until the middle of the fourth century. The ancient saddle seems to have been nothing more than a piece of cloth, leather, or hide, placed on the back of the animal, to render the seat of the rider more comfortable. The Persians were the first to use this; and to them, according to Xenophon, the invention of the saddle is to be ascribed. Saddlers' work was abundant among the Romans, saddlers and harness-makers being required to repair as well as to make the harness of the chariots, and the soldiers' helmets. Every Roman legion contained a body of horsemen, in addition to its complement of infantry.

Costume of the Romans.—Tailors, as a separate class, are not referred to until the manners of the classic

nations had changed from their early decorum to universal self-indulgence. Alpheus is described by Horace as the best and most skilful of tailors; and Helias is praised by Quintilian in the double capacity of a capital tailor and a profound philosopher. Amongst the Romans the toga was the chief article of dress. Official personages wore a red border attached, but with others it was wholly white, woven simply of bleached wool. Nevertheless, the craft of dyers was early formed into a privileged corporation; and in later times an imperial gild possessed the exclusive right of dyeing purple for the emperor's sole use. The Romans, as they advanced in power and wealth, clothed themselves in richly-coloured costumes, the ladies, especially, arraying themselves with the most costly splendour.

Except in war or travelling, the Romans seldom had any covering for the head, the toga being used like the monk's cowl, for protection when necessary. Mariners and fishermen, however, as well as travellers, wore felt hats. The hat, be it remembered, was the symbol of freedom. When a slave was ransomed or recovered his liberty, a hat was presented to him. When Nero died (A.D. 68), the citizens paraded the city in hats, to signify that they had escaped from the chains of a despot.

Hair-dressing.—The remarks upon the hair in the section on Greece might be repeated in respect of the early part of Roman history. We read of a barber or beard-shaver arriving at Rome from Sicily in the year 454 B.C. The Roman legions in the time of Cicero and Horace honoured the beard, for both refer to the frequent use of the combs by the soldiers in order to "keep their beards seemly." Greater care began at this period to be bestowed upon the hair generally, which hitherto had been kept closely cropped. The Roman women, however, at no time disregarded their hair. It was for the most part black and glossy. At home the Greek spiral top-knot was copied,

and covered with a simple net; at other times it was unconfined, and fell loosely down, being only occasionally decorated with jewellery, as on public festivals. It was then partly braided in plaits, and partly curled in ringlets, the whole forming a structure requiring divers sorts of fastenings, and surmounted with a diadem of precious stones. For dressing purposes, pomade and curling irons were used, as well as hairpins and combs. Although these essential adjuncts to the toilet must have been extensively manufactured, we have no information concerning them, or of any craft employed in making them. When the Romans became acquainted with the German tribes, the ladies envied the beautiful flaxen locks of the German women, and the art of hair-dyeing came into vogue. In general the emperors led the fashion in their sedulous care of the hair; curls were cultivated, the idea of false hair was conceived, and the peruke or wig was introduced. In Gaul the cutting off of the locks was adopted as a punishment for women; and in Germany to wear the hair long was distinctive of the free man and woman, a close cut marking the condition of the serf.

Greek and Roman Jewellery.—Our remarks upon Roman jewellery and ornaments refer also to those of the Greeks, from whom, as we have seen, the Romans were extensive borrowers. Greek goldsmiths surpassed all others in taste and skill, and their lapidaries excelled in the polishing of gems. Rings were worn upon both hands, although, eventually, the custom came to be viewed as effeminate when adopted by men. *Armillæ*, or bracelets, encircled both the wrists and the upper arms, sometimes even the ankles, and appear to have been common gifts even up to the time of the Middle Ages. The Roman women are described as wearing them of the incredible weight of from six to ten pounds. They were also given to soldiers for extraordinary valour. Rings were set with carnelian, agate, and other stones, and earrings with

pendants of pearl and jewels. Gold pins and combs, as already mentioned, were essential to the headdress of the Greek and Roman ladies, who also wore pearl necklaces, or gold wrought upon a band with a fringe of precious stones suspended. Glass beads, from the number of them which have been found in various parts, must have been much in use. Associated with them have been discovered beads of rock-crystal and agate. So lavish was the use of jewellery by the wealthy, that Pliny the Elder valued the ornaments of the beautiful wife of Caius Cæsar at a sum between £300,000 and £400,000. The cutting of signet rings was carried to great perfection in Greece, and jewels were employed to enrich the workmanship of gold and silver goblets and vases. Many of the Roman cameos are still in preservation, and distinguished by their size and splendid workmanship.

The ostentation displayed in many of the houses was even greater than that exhibited in dress. Massive silver tables, laden with gold and silver plate and costly works of art, were displayed in the apartments of the wealthy, and bowls of the same precious materials were spread before the guests at banquets. Crœsus presented to the oracle at Delphi a golden bowl weighing nine talents, and a second of silver much heavier. Such profusion of wealth rendered the goldsmith's art one of high esteem; and the names of many artists, together with their chief productions and the sums paid them for their skilful workmanship, are often referred to by both Greek and Roman historians. Silver and gold were used for coins by the Lydians, according to Herodotus, about eight centuries before Christ, but not by the Romans until between two and three centuries before our era.

Arts Relating to Metals.

Use of Iron and Bronze.—In Roman history we come fully into the Iron Period. The Romans were more conveniently placed in regard to iron-mines than either the Greeks or the Egyptians.

In the time of Polybius, the Greek historian of early Rome, iron had to a considerable extent displaced bronze in the panoply of the soldier; for while the helmet was still of this latter metal, the shield was rimmed with iron, and had a central boss of the same metal. The spear was iron-pointed, and the sword was of Spanish steel. Bronze continued to be used extensively for the capitals of architectural columns, and for doorposts; but axes, saws, chisels, and hammers were fashioned exclusively by the iron-smith. Iron appears subsequently to have been used for the whole of the defensive armour of the Roman legionaries.

The island of Elba was then, as it is now, famed for the richness of its stores of iron. Calabria also abounded in rich iron ore, and its mines were zealously worked after they came into Roman possession. With all these resources, it is still evident, from the vessels disinterred from the ruins of Pompeii and Herculaneum, that bronze-working still retained a distinguished place among the Roman arts, at least until the fall of the Empire.

In Britain, iron as well as tin had been smelted before the Roman occupation. Indeed, judging from the war-chariots furnished with axle-scythes, and from the swords and spears of the horsemen who opposed Cæsar, the art of fabricating iron must have been in a tolerably advanced state. The extensive use of iron by the Romans, and the details of the manufacture as given by Pliny, lead us to infer that an advanced knowledge of the art of smelting it was possessed by them. The present seems, therefore, a fitting opportunity to take a retrospective glance at the iron-smelter's art.

Early History of the Art of Iron-smelting.—The production of small masses of malleable iron is one of the simplest of all metallurgical operations, requiring a small furnace with a natural draught, a supply of easily reducible ore, and charcoal for fuel. Such processes as these were described by Mungo Park as being in use in Africa, and

are also still employed by the natives in Burmah. The shaft is excavated in the face of a bank, and is left exposed to the prevailing wind, several conical pipes or nozzles being inserted into an opening at the lower part. This primitive furnace is conjectured to have been used by the ancient Celtic inhabitants of the Rhenish hill countries.

Iron is divided into crude or cast iron, steel, and wrought or malleable iron. These states are essentially determined by the different proportions of carbon in combination, cast iron containing from two to six per cent., steel less than cast iron, and wrought iron a scarcely appreciable quantity.

The Greeks were acquainted with hard iron obtained from foreign countries, without knowing how the hardness was produced. As the smelting furnaces were heated with charcoal, the iron must often have been made into steel by the mere accident of the air being shut out. We have, at page 52, pointed out the probability that the Egyptians were acquainted with the use of steel. According to Plutarch, Demetrius, the son of Antigonus, had a coat-of-mail made of Cyprian adamant, which was so hard that no dart, even when thrown by a machine, could produce a dent. It seems difficult, therefore, to believe that his armour could have been composed of anything save steel. Homer refers several times to iron and steel. Probably the first important improvement in the production of iron was the substitution of the artificial blast for the natural draught. Its introduction is of great antiquity, for on the Egyptian sculptures of the reign of Thothmes III. (B.C. 1400) smiths are represented as working at a forge. They are provided with two simple leathern bellows, which are inflated by strings pulled by the hand, in a manner exactly similar to that employed in Burmah at the present time. Aristotle (B.C. 384—322) describes the Indian process of making cast steel, which is still made under the name of "*wootz*." It was produced, he says, by "heating on a char-

coal hearth about 1lb. weight of malleable iron, cut into small pieces, with about ten per cent. of dried wood, in clay crucibles, the covers of which are luted on with clay."

Diodorus Siculus (B.C. 60—40), in describing the iron-works in Elba, states that the ore was reduced to small pieces and heated in furnaces; that the charge, when properly softened, was removed, and divided into small masses of spongy appearance, which were exported into Italy for conversion into tools. Pliny (A.D. 23—79) informs us of the various methods of making iron and steel, and especially remarks that the quality of the latter depends upon the water used in quenching, and that small tools are tempered in oil. Galen (A.D. 131) tells us that knives made of Indian steel were remarkable for their strength and hardness, but were often so brittle that the cutting edge splintered off owing to their having been improperly tempered.

According to Franquoy, single-acting leather bellows with valves, were introduced by the Romans into Gaul during the fourth century after Christ. In later times wooden double bellows were used, as they still are in some parts of the Continent.

Lead-smelting and De-silverisation of Lead.—The processes of smelting lead and of separating the silver from it were known at a very early period. The Book of Job clearly describes the metallurgical and mining processes; and in Jeremiah we read "The bellows are burned, the lead is consumed of the fire; the founder melteth in vain. . . . . Reprobate silver shall men call them." This proves the knowledge of the processes of de-silverising lead by oxidation.

The chief source of silver among the ancients appears to have been the ores of lead, the silver being removed in the process of refining. Pliny informs us that lead was obtained in Spain and Gaul from deep and difficult mines. It was, however, so abundant in Britain near the surface of

the soil that a law was made to prevent more than a limited production.

Lead mostly occurs as the sulphide (*galena*), which offers no particular difficulty in the fire. By cautious roasting, its excess of sulphur may be removed, and the subsequent melting with charcoal or with a flux may be facilitated. Indeed, without roasting and a flux, the lead in many cases will flow out of the ore if placed among flaming wood or peat, and subjected to a sufficient stream of air; but the use of fluxes could not long remain unknown in the limestone districts of the North of England—limestone and fluor, the latter so called by the Romans because "with the heat of the fire, as ice by the sun, it melts and flows," being to this day valuable fluxes. Peat was the fuel in Cornwall, and is still used in Yorkshire; and perhaps the Roman smelters did really erect their furnaces on waste grounds and heaths at Dacre and Matlock, far from their mines at Greenhow and Youlgreave. Crucibles, bellows, chimneys, and carbonaceous fuel were certainly employed by the ancients; and the power of purifying and alloying appears quite conspicuously among the ancient arts. The smelting of lead was vigorously pursued by the Romans, and the metal was regularly exported from Britain. Their process was, however, wasteful, and it has proved profitable in more modern times to re-smelt the immense mounds of slag left by them. These cinder-heaps, in some counties called "Danes' cinders," indicate the great extent and duration of this ancient industry.

Arms and Armour.—From the evidence afforded by statues and by the representations on vases, coins, and gems, we learn that the style of Roman armour was borrowed from the Greeks, and that though it suffered mutations with the lapse of time, it was always simple, consisting of helmet, shield, lorica or cuirass, and greaves. Subject to the changes to which we have had occasion to refer already, these may be thus described—the helmet was

originally composed of leather, and the lorica was composed of bands of brass imbricated or overlapping like tiles, and very heavy, sometimes enriched with devices on the breast, skirt, and shoulder-straps. A sword-belt was thrown across from the right shoulder to the left side; and a shield of a square shape, with the device of the legion, was fastened to the left arm. Amongst the antiquities preserved in the British Museum are the bronze back and breast of one of these Roman suits of mail. The Britons, whilst under the Roman yoke, exchanged their armour of skins for the leather cuirass, which they continued to use until the time of the Saxons, whose leader, Hengist, is said to have worn scale-armour, and his followers loricæ of leather, and four-cornered helmets. Their weapons consisted of swords and spears, and they carried oval shields upon their left arms.

The Locksmith's art was improved by the Romans, whose practice it was to keep their coffers or money-chests, stoutly defended by clasps and locks, in the halls of their houses, for purposes of display. The Roman palaces contained an enormous number of rooms, lavishly supplied with secured doors, the keys of which were not unlike our picklocks. The spring-bolt was not known to the Romans, although their locksmiths' work reached a high degree of excellence. Locks for some purposes were so large that the key was made to turn upon a swivel, while others were so small that the openers, inlaid with the signet of the possessors, were mounted as finger-rings. The Romans were likewise acquainted with the use of movable locks or padlocks.

Intellectual Arts.

Literature and Science.—The use of the papyrus by the Romans dates from an early period in their history. The books of Numa and the Sibyl are said to have been made of this material. As they derived cultivation and science from the Greeks, so their writing materials

were such as were in use among that people, except that in the later centuries before Christ, parchment was added, and from that time became the general material for writing upon. The Latin alphabet, derived from the Doric colonists of Cumæ and Sicily, was another offshoot of the Phœnician characters used in the Greek alphabet. The Romans first committed to writing their laws and public documents, which were preserved or set up on pillars in the public places, and also in the temples of their gods. They were almost without a literature of their own until they became acquainted with the Greeks. Their works treat more of history, jurisprudence, and geography than of philosophy and poetry. Pliny the Younger, it is true, wrote a treatise on natural science, consisting of no less than thirty-seven volumes, but this was merely an abstract of more than 2,000 other books. The first public library was established by Paülus Emilius, who brought from Greece the library of Perseus, King of Macedon, after the conquest of that monarch. Soon after, private collections were made in villas and country towns, as well as in the metropolis itself, and the possession of a library and reading-hall became the mark of a house of distinction. The library hall was provided with numerous windows; in the centre, sofas were placed here and there for the benefit of readers, whilst the books and rolls were arranged in separate framed cases around the walls. The works required for reading were brought out in cylindrical boxes of bronze, called *cistæ*, and placed on the floor beside the student. The papyri stood upright in the box, and were taken out of it by a strip of parchment attached. The reader fixed one end by his chin, unrolled as far as he required, and then held the roll with both hands. The space occupied by ancient libraries appears to have been very considerable. From the portion of the "Iliad" found in Egypt, which was eight feet long and ten inches wide, it has been calculated that a copy of the works of Homer would require forty-one such rolls. In the Alexandrian

Library, Homer's works and those of his commentators were placed in a special room, in 1,000 rolls.

The most remarkable of the Roman papyri are those found at Herculaneum in A.D. 1753, completely reduced to carbon by the effects of the eruption of Vesuvius. The first successful attempt at unrolling was made by Piaggi, at Naples, in 1758; since that date no improved method has been discovered. There were 1,756 rolls found, and the work of unrolling still proceeds, although slowly, the process requiring much care and experience. Not more than an inch can be done in four or five hours, and it required four years to unravel thirty-nine pages of Philodemus on Music, and one year and a half to perform the same operation for twenty-nine pages of rhetoric. Since their discovery, the interest in these papyri has greatly diminished, as the contents thus far have not been of much literary value.

Along with the public and private libraries, copyists and booksellers necessarily arose. The copyists all wrote with the *calamus* (a Carian or Egyptian reed), and with ink made from soot, burnt pine-wood, pitch, or resin. Special writers, called *chrysographi*, wrote in letters of gold. The writings or books were twisted round a stick into a cylindrical form, each cylinder being called a *volumen*. The works discovered at Herculaneum have the stick (*bacillum*) concealed within the rolls, not, as usual, projecting from them, and possess in some instances a portrait of the author.

Public academies were first instituted at the expense of the State in the time of Augustus. Most of the important towns of the Roman Empire followed the example set by the metropolis, and we find such buildings, with their respective societies, reared and conducted by the citizens of Marseilles, Athens, and Constantinople. Thus it was that Latin became, and has still continued to be, the language of study in colleges and universities.

With respect to the scientific knowledge of the Romans, all their mathematical and even their mechanical know-

ledge was derived from Greece. The work of Vitruvius, on Architecture, written in the reign of the Emperor Augustus, is the only source of reliable information as to the machines then in use. It appears that the mechanical powers known were the lever, the pulley, and the windlass; that the muscular strength of men was employed as a motive power in turning mills; and that wheels were used for raising water in buckets, and for grinding corn. Vitruvius also describes minutely those ancient war-engines, the *balista* and *catapulta*—the former for throwing heavy stones, the latter for propelling darts and arrows. Pliny and Seneca speak of magnifying by concave lenses; and in Pompeii stones have been discovered which could only have been cut under a microscope, such is the minuteness and delicacy of the workmanship.

Music.—Lucretius, in one of his poems, declares that the birds were the first instructors of man in the art of song, and that the musical sounds produced by the reeds of the marshes when the wind swept over them suggested to mankind the first idea of wind instruments. The Romans undoubtedly derived their knowledge of music, as of so many other arts, from the Greeks. They appear to have been perfectly satisfied with the state in which they received it, and no historical evidence can be adduced to show that they contributed anything towards its advancement. Indeed, there is not one instrument which can be truly called a Roman invention. That they appreciated music must be admitted, from the fact that it was employed to animate their troops in battle, and to give effect to the triumphal processions of their victorious generals, that it formed part of their delight in the theatre and at the public games, and that it was used in religious ceremonies and funerals. From the custom of introducing it into the last offices of the dead, arose the common saying, "*Jam licet ad tibicines mittas*" (You may now send for the flute-players). Even in the celebrated Augustan age, when

literature, science, and art were in their most flourishing condition, the Romans had no native painter or musician, all who practised these arts being foreigners—either Asiatic or European Greeks.

PART II.

MEDIÆVAL INDUSTRIAL ART.

INTRODUCTORY CHAPTER.

THE Middle Ages occupy a period of about ten centuries. They extend from the fall of the Western to the final overthrow of the Eastern Roman Empire; from the taking of Rome by the Goths, under Odoacer (A.D. 476), to the capture of Constantinople by the Turks, under Mahomet II. (A.D. 1453).* Of these centuries, the first six, or the time intervening between the fall of the Roman power in the West and the commencement of the first Crusade, A.D. 1096, have been called by historians the "Dark Ages." They indicate a state of society which it is to be hoped will never recur. Ancient literature was destroyed, works of art were burned, palaces, theatres, and temples—colossal and magnificent—were ruined and razed, and the flower of the Roman people perished by the sword.

The Goths, Vandals, Heruli, and other hordes are not to be held wholly responsible for this destruction. A great deal of it was the result of the anti-pagan zeal of some of the early Christians, who ruthlessly destroyed the images and shrines of the Greeks and Romans. The finest productions of sculpture thus fell before the ardour of the

* The limits set by the historian of the Middle Ages are "The Invasion of France by Clovis" and "that of Naples by Charles VIII." —See Hallam.

Iconoclasts, as the image-breakers were called. This destruction commenced in the reign of Constantine, and was carried on with such vigour and sternness that when the Emperors Arcadius and Honorius (A.D. 395), issued fresh edicts for pursuing the work, a qualifying clause was inserted which ran as follows: "*Si quæ etiam nunc in templis fanisque consistunt*" (If, indeed, any still remain in the temples and shrines). Theodoric, and subsequently Charlemagne, attempted in vain to stop this excess of zeal. The latter even formed the plan of surpassing the splendour of ancient pagan art by the magnificence of Christian design; and, indeed, this project would certainly have been accomplished had the age been worthy of the grand conceptions of the great emperor. The resuscitation of art and science belongs, however, to another period.

Up to the time of Constantine, the Church had been independent of the State. By their union the latter acquired wealth and rank, but its simplicity and purity became so corrupted that it required a period of more than a thousand years, together with much sacrifice, even of life, to restore it in some measure to its primitive condition. Not without reason have the apologists for the clergy affirmed that image-worship was insisted upon by the people, and that the Church had to admit ideas which, after centuries of apostolic labour, she has been unable wholly to eradicate.

CHAPTER I.

ARTS RELATING TO THE SUPPLY AND PREPARATION OF FOOD.

SECTION I.—AGRICULTURE AND HORTICULTURE.

MUCH of Europe was, in the early centuries of the "Dark Ages," without towns worthy of the name, the population leading a warlike and unsettled life, and devoid of all but the most elementary knowledge of the industrial arts. Agriculture at this period was perhaps at the lowest ebb that it has ever reached. The warlike habits of the Northern tribes were little calculated to encourage labours which they held in comparative contempt.

Very different were the effects, during the tenth and eleventh centuries, of the rapid conquests of the Saracens. Their march was followed by a development of agricultural knowledge. Besides originating new methods, they adopted from the conquered people whatever might be found useful or profitable in the methods prevalent among them. In Egypt and Persia ample scope occurred for introducing science into the labours of the field. The artificially-watered plains of Syria soon displayed that Saracen ingenuity which was afterwards carried to perfection in Spain, where agriculture attained a degree of excellence before unknown, and, except in the Netherlands, never afterwards paralleled in Europe. By the skill they had acquired in the processes of irrigation—the first great requisite of Southern agriculture, as drainage is of the Northern—the Moors of Spain created a new era in European husbandry. Canals, reservoirs, and aqueducts were carried through every district where such aid was required. The Moors also introduced and naturalised the most useful of the medicinal as well as of the agricultural plants of Asia and Africa, and cultivated many of the indigenous products of Southern Europe. The

revenue of Spain, which chiefly represented the practical results of the agricultural labour of the people, was during the reign of Abderrahman III. equal to £6,000,000 sterling —"a sum," remarks Gibbon, "which, in the tenth century, probably surpassed the united revenues of all the Christian monarchs."

In our own island, agriculture has passed through many phases. Hallam points out how war and the chase could not afford the Saxon and Norman kings much scope for industrial improvement. He writes: "The excessive passion for the sports of the field produced those evils which are apt to result from it—a strenuous idleness, which disclaimed all useful occupations, and an oppressive spirit towards the peasantry. The devastation committed, under the pretence of destroying wild animals which had been already protected in their depredations, is noticed in serious authors, and has also been the topic of popular ballads. The levelling of forests, the draining of morasses, and the extirpation of mischievous animals are the first objects of man's labour in reclaiming the earth to his use; and these were forbidden by a landed aristocracy, whose control was unlimited, and who had not yet learned to sacrifice their pleasures to their avarice. . . . Yet, even in the least civilised periods, there were not wanting partial encouragements to cultivation. The devastation of war from the fifth to the eleventh century rendered land the least costly of all gifts, though the most valuable and permanent. Many of the seemingly large grants of land to monasteries were absolute wastes, and could probably be reclaimed by no other means. We owe to the monks the agricultural restoration of a great part of Europe. They chose, for the sake of retirement, secluded regions, which they cultivated with the labour of their hands. Several charters are extant of lands which they recovered from a desert condition."

From the time of the Saxons down to the Reformation, dykes were constructed, fens drained, and the soil improved

by the religious houses. The monks were truly not only the most advanced agriculturists, but the first landlords, in the best acceptation of the word. They were, moreover, instructors; and their revenues being paid in kind, it was their temporal interest to increase the permanent as well as the immediate productiveness of the lands over which they exercised control. Again, they kept alive the embers of a past civilisation by their intercourse with Rome, which city became a centre whence radiated, among other things, a practical knowledge of husbandry. The results of the combined experiences of the whole Catholic Church of the West, would be more or less perceptible over the lands of proprietors thus comparatively enlightened.

To particularise the efforts of the monks in this direction, we find that, in the seventh and eighth centuries, they penetrated primeval forests, disputed with wild animals the possession of the soil, founded settlements, and taught the people the first principles of agriculture and handicraft. Such men were Columbanus, Gallus, and Bonifacius, who established as the firstfruits of their labours the cloisters of St. Gall, Weissenburg, Reichenau, Fulda, and Lersch.

Many such arose, and we soon find at Constance, as signs of a practical utilitarian advance, cooks, innkeepers, fullers, gardeners, tailors, millers, sword-cutlers, shield-makers, brewers, and glass-burners. The gardens, vineyards and fields of the monks became models for the people. The cultivation of various kinds of fruits, especially, took its rise in the monasteries. In the ninth century gardens are mentioned in old documents, under the name of "*Pomaria*," and botanical gardens are also named. In the eleventh century, in the convent gardens of Hirschau, under the abbot Wilhelm, apples, pears, peaches, medlars, quinces, large and small nuts, plums, cherries, grapes, and various kinds of red and black currants were planted and reared.

The motives of the priests for teaching the people agriculture are well illustrated by the following extract

from Maltebrun, vol. vii., p. 109:—"Otho, Bishop of Bamberg, styled in their legends the Apostle of Pomerania, visited the country A.D. 1124, for the purpose of converting the inhabitants. He observed that the art of making hydromel—a fermented liquor made from water and honey—was well understood. He thought it, nevertheless, unbecoming to substitute it for wine in the sacrament of the Lord's Supper. When, therefore, the same bishop returned, in 1128, he carried away with him a large cask filled with young vines, which were planted, in order that he might minister wine to his converts. At that period laymen, as well as ecclesiastics, partook of the communion in both kinds. It is owing, doubtless, to the same cause that the culture of the vine was introduced with Christianity into different Northern countries. Mœhsen affirms that the difficulty of obtaining wine in the North gave rise to the custom of communicating in one kind. The first wine drunk by the inhabitants of Pomerania was that received at the sacrament from the hands of their bishop, who succeeded, after an incalculable amount of labour, in accomplishing the object upon which he had set his heart, and which was almost the work of a lifetime."

Charlemagne was the first prince who encouraged agriculture in Germany. He had about seventy farms in different parts of his dominions, to which storehouses and granaries were attached, all being under his own or his agents' supervision. Among those who were thus employed, a great variety of servitors are mentioned. Similar farms were owned by the dukes, earls, and other nobility of the Court. In the ninth century, the monastery at Constance had 160,000 acres under cultivation, together with an oven capable of baking 1,000 loaves at a time. The dough was made up, without leaven, of barley, oats, and spelt, the flour being very coarse. This was however soon superseded by leavened loaves, made of wheaten flour, and called fine or white bread.

Agriculture at this time was restricted to the south of Germany, for the climate in the north was too cold for the successful cultivation of corn. In the capitularies of the Emperor Charlemagne, express orders are given as to the general plan for the laying out of farms, and mention is made of the very plants which were to be cultivated on them. There were grown, besides the common kitchen vegetables, such as lettuce, celery, parsley, carrots, parsnips, radishes, turnips, onions, cucumbers, gourds, and melons, the following pot-herbs and flowers: sage, rue, rosemary, wood-mint, water-mint, cat-mint, wild thyme, tansy, marsh-mallows, hollyhocks, lilies, poppies, and roses. There was a noble supply, too, of fruit-bearing trees—the apple, pear, plum, cherry, medlar, quince, and peach. In addition to these, oats, wheat, barley, millet, buckwheat, rye, beans, lentils, and pease were also grown, together with certain vegetable productions used in the manufactures of this period, such as madder and woad, flax and hemp.

Cattle-breeding and Swine-herding.—Cattle-breeding and swine-herding formed an important branch of rural economy. The German pasture-grounds for horses, oxen, sheep, and swine were held in high repute in Rome; nevertheless, the stock raised was of a very inferior character, since the animals were herded in the wastes and woodlands; and beasts in good condition were rare, owing to the want of really good pasturage during the summer months, and the inadequate supplies of food for the stock in winter. In the sixth and seventh centuries taxation was mainly regulated by the amount of property in cattle; cattle were also given as dowry, and constituted the only fortune which the husband received with his wife.

The rearing of swine was a prominent feature in the husbandry of the Middle Ages. The extensive forests supplied beech-nuts and acorns in abundance, for the sustenance of these animals: forests, indeed, were usually valued according to the number of swine they were capable of feeding.

We find in Domesday Book that forests were estimated at so many *hogs*, pastures at so many *ox-gangs*, and arable land at so many *plough-gates*. In such a condition of stock-farming it was necessary, owing to the scarcity of fodder, to slaughter a portion of the animals in the fall of the year, and to pickle and salt the meat for use in cold weather.

Although game was very abundant, and was carefully preserved, eggs, meat, and farinaceous food formed the chief articles of consumption. Culinary herbs and vegetables were very sparingly grown. All aromatics were designated by the name of pepper, a favourite imported spice, which was used in many cases for money, the payment of tolls, &c.

Restrictions on Agriculture.—In the Middle Ages agriculture was greatly retarded by the system of villeinage and by the frequent feuds between the nobility. Periods of scarcity were of common occurrence. No fewer than four famines are said to have been experienced in the fertile plains of Lombardy during the first half of the thirteenth century, followed immediately by another in 1257. It was on this account that the importation of foreign corn was favoured. Indeed, in several important towns it was admitted duty free, as at Freiberg in 1307, and at Nürnberg in 1350. Over all Europe throughout the mediæval period the condition of the labourer was the same, the agricultural and industrial arts being in the most abject condition. Under the system of feudalism, vassals were everywhere liable at any moment to be called upon to fight for the noble to whom they owed allegiance. The restrictions to which the industrial classes were subjected by their civil and religious rulers are well illustrated by the following curious historical facts in reference to the construction of windmills. It would appear that land proprietors considered the wind, if it could be utilised, to be as much their private property as the woods and waters upon their domain. On this subject Beckmann, in

his "History of Inventions," vol. i., p. 169, writes as follows: "The oldest example of this with which I am at present acquainted is related by Jargow. In the end of the fourteenth century the monks of the celebrated but long since destroyed monastery of Augustines at Windsheim, in the province of Overyssel, were desirous of erecting a windmill not far from Zwoll; but a neighbouring lord endeavoured to prevent them, declaring that the winds in that district belonged to him! The monks, unwilling to give up their point, had recourse to the Bishop of Utrecht, under whose jurisdiction the province had continued since the tenth century. The bishop, highly incensed against the pretender who wished to usurp his authority, affirmed that no one had power over the wind in his diocese but himself and the Church at Utrecht. He, therefore, immediately granted full power, by letters patent, dated 1391, to the convent at Windsheim, to build for themselves and their successors a good windmill in any place which they might find convenient. In the like manner the city of Haarlem obtained leave from Albert, Count Palatine of the Rhine, for a similar purpose, in the year 1394."

Influence of the Crusades.—The spirit of military enterprise survived in Europe after the invasions of the barbarians from the North and East had ceased. The Crusades, in a remarkable degree, afforded vent for the exercise of this disposition, and, at the same time, they relieved agriculture, and every other branch of industrial art, by putting an end to the system of feudality.

The absence of the feudal chiefs relaxed the grasp of tyranny, and left the serfs unfettered on the soil; whilst every crusader was an eye-witness of the advantages derived by the possessors of the Holy Land from the progress they had made in agriculture. Each survivor, on his return, would probably strive to apply the knowledge thus gained to the improvement of his estates, and thus add to the variety of native produce. About this time Europe received

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the roses of Jericho and Damascus, and the Turkish plum. It was during the Crusades that many of the modern cities of Europe arose, and that trade and commerce began to revive. The enthusiasm for the Holy Land laid hold on all classes. The great barons sallied proudly forth with their retainers; but on their return, humiliated and impoverished by defeat, they were reduced to seek help from their inferiors. Estates were then sold to the city merchants, who had profited by quietude at home, and had acquired wealth; and soon, also, many of the most skilful of the operative class were, by their savings, enabled to free themselves from a state of vassalage.

SECTION II.—THE BAKER.

Bakers, in common with other crafts, participated in the movements of the age, and began to consult their own interests by combining in guilds. We find them mentioned (1111), in the reign of the Emperor Henry V., in a document which secures certain rights to bakers, butchers, and others, besides protecting them against acts of violence and injustice. Bakers are also mentioned as existing in Augsburg in 1156, in Breslau in 1271, and in Frankfort in 1387.

Germany soon became celebrated for its bakers. In the twelfth and thirteenth centuries, besides the common round or triangular flat loaves—which, as among the Greeks, supplied the place of spoons and table-napkins—cracknels, brushed over with oil, were made, together with fritters, pancakes, &c. In the fifteenth century German bread alone was eaten by the rich citizens of Rome, and German bakers were domesticated in Venice and other Italian towns.

Public bakeries were established in 1276, and inspectors appointed to examine the bread as to its purity and weight. This inspection, together with the taxation on the material, sometimes led to turbulent scenes between the people and the authorities. Halls were erected for the sale of bread, and in Vienna and many other places the amount

baked daily or weekly was regulated by law. In many towns there were public scales, at which citizens could weigh their corn food. The oldest measure was the *muta*, or *modius*. In the thirteenth century the peck was a common one. Fine, imprisonment, the pillory, and the gibbet were the punishments awarded for possessing and using false weights and measures. The gibbet was erected over a slough or puddle in the middle of the town, and the offending baker was placed upon it. There he remained until he thought proper to adopt the only means of escape—jumping from the gibbet into the midst of the mud, and beating a retreat amid the ridicule and laughter of the crowd. This punishment was actually inflicted in Zurich (1280) and in Augsburg (1442). The Parisian bakers were not allowed to work on Sundays or festival days. A law was passed which compelled them to bake three kinds of bread daily. They were permitted to make rolls, but not to sell them under a penalty of 400 livres, or about £12 sterling.

In the laws of the four burghs of Scotland—Berwick, Edinburgh, Roxburgh, and Stirling—bearing date in the eleventh century, we find it ordained: "Nane aldirman, bailze, nor bedell sall bake brede nor brew ale, to sell wythin thair awin propir hous, durande the tyme that thai stand in office." Also, "Baxtaris" (bakers) "that bakis brede to sell, sall bake quhyte brede and grey, eftir the consideratioun and prise of the gude men of the toun, eftir as the season askis. And quha that bakis brede to sell aw nocht for to hide it, but sett it in thair window, or in the mercat, that it may be opynly sauld." Such were some of the injurious restrictions to which artisans were formerly subjected.

SECTION III.—THE BUTCHER.

It is difficult to fix the price of meat in the Middle Ages, as the value of the coinage of that time is not easily determined. With improvements in husbandry, better breeds of cattle were produced, and the consumption

of animal food became more general. In the fourteenth century the old forests had been extensively cleared, some of the meadows were mown two or three times in the year, and in Lower Germany and Holland the rearing of horned cattle had attained to a very flourishing condition. At Marienburg, in Prussia, in the fifteenth century, beef, veal, mutton, pork, game, and poultry were well-known viands at the hospitable table of that princely court; and at German festivals and marriage celebrations amongst the nobility and princes, in the fifteenth and sixteenth centuries, immense quantities of animal food were consumed. Even in the private houses of wealthy and substantial tradesmen the consumption of meat was often enormous.

The importance of the butcher's craft towards the close of the Middle Ages is evinced by the numerous jovial festivities and processions held by them. Thus, the butchers at Königsberg held an annual procession, in which a monstrous sausage was borne through the town; similar festivals were held at Nürnberg, Zittau, Vienna, and Munich, all concluding, naturally enough, with a ball and a banquet. In the towns of France, on Shrove Tuesday, a fat ox, with its horns gilt, and ornamented with ribbons and flowers, was led through the streets, followed by butchers both on horseback and on foot, all dressed in appropriate costume. They were preceded by bands of music, and by representations of heathen divinities, drawn in a richly-gilt triumphal car. This old custom is still kept up, even in Paris, and forms one of the most curious pageants of modern times.

During the fourteenth century French butchers were subjected to so many regulations that they could carry on their trade only with great difficulty. They were forbidden to buy cattle except in the markets, to purchase pigs fed by barbers or oil-dealers, to kill cattle on the eve of fast days, and to sell their meat by the light of a candle or lamp; nor could they legally keep meat more than a stipulated time in summer or in winter.

SECTION IV.—THE BREWER.

Tacitus speaks of an intoxicating liquor extracted from barley, which seems to have been made and consumed in large quantities in Germany. This drink did not resemble the beer of subsequent times, but was only a liquor somewhat of the nature of wine, produced from fermented corn, and seasoned with a decoction of oak bark. That this was the general beverage which the Germans must have used for centuries, there is no doubt, since the cultivation of hops, owing to the severity of the climate, was late in introduction, and was only slowly developed by industrial skill.

Besides that brewed from barley-malt without hops, a beer was made by the Germans during the Middle Ages from oats and wheat. Bishop Salamis, of Constance, A.D. 915, showed the imperial messengers of the Exchequer an oat-kiln for the preparation of 100 measures at one time. The oats were mixed with the wheat, of which latter the Prebend of Münster is said to have received annually several measures, for the preparation of a superior kind of beer. The use of any grain but barley in brewing was prohibited in Nürnberg, A.D. 1220, and in Augsburg, A.D. 1433, oats only being allowed. There was also a kind of beer mixed with wine, and another sort in the preparation of which honey took the place of wine. The first of these was prohibited by the Council of Aix, in 817; and under Conrad III., 1147, we meet with the registration of a tax of thirty pints of mead, twenty of honeyed beer, and sixty of beer without honey. In order to impart a more agreeable flavour, the brewers in Ulm were accustomed to use cinnamon, cloves, wormwood, juniper, and masterwort, all other ingredients being expressly forbidden.

In the Netherlands a beer was made called "*gröt bier*," probably composed of herbs capable of fermentation. In a document of 1260, this beer is expressly called "*fermentum*," implying the process of fermentation, and that the sediment

of oats was the chief matter in its preparation. In the time of Otho III., 939, we meet with a fermented beverage called "*gruit*," composed of different aromatic herbs. Lastly, a very inferior kind was made of oats, in which ash-leaves supplied the place of hops; of this we are informed by the Abbess Hildegard.

Large quantities of mead were also drunk in Germany during the Middle Ages. These various kinds of liquor were used much in the same way as we now employ tea and coffee, which had not then been introduced into Europe. Mead was made of very superior quality in the Netherlands, Saxony, and especially in Swabia, where much honey was procured from the Alps. In the Netherlands it was prepared by the domestics upon the farms of the provinces. In later times, that made in Bruges and Ghent was celebrated for its superior flavour. So plentiful was it in Meissen, A.D. 1015, that when a fire broke out and the water failed, we are told that it was extinguished with mead. Towards the end of the twelfth century large quantities were sent down the Danube, through Lower Austria, by way of Constantinople, to Syria and Palestine; and we read of the mead breweries of Dantzig and Riga as existing and famous in the fourteenth century. At the Court of the Grand Master of Marienburg it was usual to drink it pure and good out of small glasses; then followed high glasses for a stronger quality, which latter was generally procured from Riga. Towards the end of the Middle Ages, however, as improvements were effected in the making of beer, the manufacture of mead declined.

Use of Hops.—Beer brewed without hops soon turned sour; the length of time, however, during which it remained good depended very much on the season when it was brewed. Laws were therefore enacted which restricted brewing to certain portions of the year. The use of hops is undoubtedly a German discovery, and appears to have been made under the Carlovingian dynasty, in the ninth

century. Hop-grounds, in the Frisingen collection of ancient documents, are spoken of, under the name of "*humularia*," as existing at that period to some extent in Germany. It is certain, moreover, that the method of seasoning beer by hops was adopted at a much later period by the English, Dutch, Swedes, and other European nations.

Hops were cultivated in the South of Germany in the eleventh century; and in the first half of the thirteenth the art of brewing with them was universally practised at Ratisbon. Hops were also used in the beginning of the fourteenth century in the breweries of Flanders, for about this time we find complaints that the new method lessened the consumption of the fermented beverage called "*gruit*," and the tax, "*gruit-geld*" arising therefrom. Thus John, Bishop of Liége and Utrecht, complained to the Emperor Charles IV. that for thirty or forty years a new mode of brewing—that is to say, with the addition of a certain plant called "*humulus*," or "*hoppa*"—had been introduced, and that his income arising from the *gruit-geld* had been thereby much lessened. The Emperor (A.D. 1364) permitted him, for the purpose of making good his loss, to demand a groschen for each cask of hops, and this right was confirmed to Bishop Arnold by Pope Gregory.* About this time regulations existed in Zittau for brewing two kinds of beer, wheat or drinking-beer for immediate consumption, and barley-beer for keeping. It is, therefore, not at all improbable that hops were used in the preparation of the latter. In the monasteries, too, after 1482, two kinds are mentioned, the stronger one, "*paternus*," the weaker kind called "convent-beer." In fact, from the fourteenth and fifteenth centuries, hops were in general favour throughout Germany, and much greater skill was acquired in the art of brewing.

Varieties of Beer.—Several places in Germany acquired considerable renown for the superior excellence of their beer. The towns of Lubeck and Rostock, for instance,

* See "Beckmann's History of Inventions," Vol. II., p. 383.

became celebrated for their double beer, or Brunswick Mumme, so-called because said to have been first made by a citizen of that name. This drink, of a deep brown colour, resembling syrup, and having a sweetish taste, was manufactured in enormous quantities. Rostock alone annually exported 800,000 barrels to all parts of Germany and Europe. The Marseburg beer was also renowned as a peculiarly wholesome drink. The beer of Zittau, already mentioned, was largely consumed in Prague. The "*markische*" was much esteemed, not only at home, but in foreign countries, and, together with the Einbecker beer, was exported to England. We have it on record that Duke Eric of Brunswick sent to Luther, at the Diet of Worms, a bottle of the latter kind. In the same century large quantities of beer were exported from Lubeck to the North; and it is said that the Danish and Swedish kings and nobles did not know how to enjoy themselves unless they had a flask of Lubeck beer at their elbows. Besides these kinds, several varieties of light beer were brewed. The irrepressible gaiety of the period is shown in the very humorous names which were sometimes given to these drinks.

The first book on beer and the art of brewing was printed at Erfurt, A.D. 1575, with this title: "Five Books upon the Divine and noble Gift, the estimable, philosophic, and wonderful Art of Brewing. By Herr Knausten, Doctor of both Laws." This work contains a description of all the different kinds of beer then in use in Germany, with their peculiar properties. It would appear that the Hamburg was then considered to be the best of all the light kinds; that of Dantzig the best beer made of barley and rye; then follow in order those of Lubeck, Rostock, Bremen, Stade, Elbing, Stralsund, Stettin, and other places.

The following are some of the towns in the Netherlands and in Germany in which brewing was first followed as a distinct trade. Breweries were established at Grommel, in Guelders, A.D. 999; at Utrecht, Hammersfort, and Delft, in

Holland; at Nivelle, in Brabant, A.D. 1209; at Bruges, in Flanders, and at Ghent, from which place beer was supplied to Prussia. In Cologne, at the beginning of the thirteenth century, brewing was a common branch of industry; and about the same period at Bremen, Hanover, Magdeburg, and Bernau the trade had been firmly established. In the South of Germany, where hops, as we have already seen, were cultivated in the eleventh century, Ratisbon especially deserves notice for its numerous breweries.

Brewing in England.—After the Romans had taught the ancient Britons agriculture, beer became the national beverage. The mode of making it in the fifth century is thus described by Isidorus and Orosius: "The grain is steeped in water, and made to germinate. It is then dried and ground, after which it is infused in a certain quantity of water, which, being fermented, becomes a pleasant, warming, strengthening, and intoxicating liquor." Barley was the grain most frequently used for this purpose, but occasionally wheat, and also oats and millet. Both ale and beer are mentioned in the laws of Ina, King of Wessex, who was crowned A.D. 689; and we have records which prove that both were furnished for a royal feast in the reign of Edward the Confessor. A statute was enacted, A.D. 1260, in the reign of Henry III., fixing the price of ale throughout England. Tindal, an old English writer, speaks of the "dutie of the bruer to serve his brethren faithfully;" and Stow, A.D. 1414, describes "one William Murle, a rich maultman or bruer, of Dunstable, who had his two horses, traped with golde, following him, and a pair of gilt spurs in his bosome."

It is certain that bread and ale were both regarded as necessaries of life in these early times, and that the latter was as much a part of an English breakfast as tea and coffee are in the present day. In the Household Book of the Earl of Northumberland, the following is the record of the daily bill of fare: "On flesh days through the year, breakfast for

my lord and lady was a loaf of bread, two manchets, a quart of beer, a quart of wine, half a chine of mutton, or a chine of beef boiled. On meagre days, a loaf of bread, two manchets, a quart of beer, a quart of wine, a dish of butter, a piece of salt fish, or a dish of buttered eggs. During Lent, a loaf of bread, two manchets, a quart of beer, a quart of wine, two pieces of salt fish, six baconed herrings, four white herrings, or a dish of sproits."

The English monasteries were always noted for possessing the best wine and ale, which last the monks themselves brewed with great care and skill.

SECTION V.—THE INNKEEPER.

Inns, in which travellers could meet with the accommodation they needed, were only established when both the land and the people had arrived at a certain degree of cultivation and refinement; mediæval history is, therefore, silent for some centuries upon the existence of inns and public-houses. In early ages the Germans were celebrated for their hospitality, their love of society, and their carousals. The historian Tacitus mentions these facts as characteristic of a people who were unwilling that even travellers should pass their nights without food or shelter. Inland and foreign commerce and travel were greatly restricted until the time of the Crusades, when an extensive intercourse with foreign lands began to be opened up. The Danube became a means of communication with Constantinople; and, through the narrow defiles of the Alps, trade was opened with Italy and the Mediterranean. The Hanse Towns also established a connection, by means of their ships, with the North of Europe. Commerce thus became more flourishing, and simultaneously inns were inaugurated, and social convenience greatly promoted.

It was the peculiarity of a time when nice distinctions separated the different grades of society, that every man

strictly adhered to his own rank and station in life. Thus the higher grades had their wine and drinking saloons, the craftsmen their taverns and gild-houses, the clergy their drinking-rooms and stores, and the rest of the population their social gatherings in cellars. Several of these last have retained their celebrated names to the present day, as the Rathskeller, at Bremen, the Auerbachskeller, at Leipzig, and the Kornhauskeller, at Berne.

All these establishments for shelter and refreshment early attracted the attention of governments. In 1156 we meet with regulations as to lodgers at the public-houses, and as to the time of closing. In France only such persons might be lodged as had no dwelling in the town. In several cities, as in Ratisbon, no beer was allowed to be sold after the sounding of the evening bell, which was thus called the wine or beer bell. Laws were also established forbidding the adulteration of liquors, and licences were granted permitting only certain individuals to retail them. In Zurich and Frankfort it was attempted to prevent the adulteration of wine with chalk and alum; and in 1360 the people of Frankfort were induced to forbid its mixture with brandy—the first mention of this spirit. In Vienna, Ratisbon, and Nürnberg, it was enacted that no wine should be sold without its having been previously tested by persons of sworn skill.

After the thirteenth century innkeeping became a more important branch of industry, and those licensed to sell wine and beer carried their monopoly so far as to obtain special statutes from the sovereign. Some of these regulations expressly enjoined that none but citizens should keep a wine-house or tavern, and forbade the building of a wine-house or brewery within a mile of the city. This law was entitled the mile or ban-right, and was strictly observed. On this account the magistrates themselves erected taverns, and sold beer for their own advantage; hence the appearance of town-council cellars. In 1367 such a building is men-

tioned in Ulm, and in 1463 in Erfurt. Similar enactments existed in reference to the wine-houses belonging to the liege lords. In many places, on festive occasions, these lords alone possessed the privilege of tapping wine. This was called the wine-ban. A restriction of this kind was annulled as early as 1111, by Henry V., for the city of Worms, and Strasburg purchased a similar favour of its bishop for 400 marks of silver. The keeping of wine-houses soon obtained the dignity of a special calling, and in large places wine-markets and wine-rooms were established, in which the beverage was retailed. It is related of the Abbot of Munster, in the St. Georgenthal (1339), that he held firmly to his right of exclusively retailing wine three times in the year, at Christmas, Easter, and Whitsuntide. The monastery at Stein, on the Rhine, had, it appears, in 1267, this right over their possessions at Klingen, on Martinmas, St. George, and Midsummer days.

In the fourteenth and fifteenth centuries the general progress of society rendered innkeeping increasingly prosperous. By degrees the restrictions imposed by the beer and wine mile were removed, the result of which was that every village was provided with its public-house. The Germans still retained their old love of festivals and strong drink; and their powers of imbibing liquor were truly astonishing. Many examples might be adduced, but it must suffice here to mention that on one occasion, according to chronicles still preserved, sixteen students drank at a single feast 200 pints of Wurtemberg wine. Enough of this subject, however. As we have already seen, in Section II., the men of these times were great eaters as well as drinkers. Besides the flesh of the domestic animals, bear, and venison, with game, were ordinary dishes at the public table. In the twelfth and thirteenth centuries, not only pheasants, fowls, and ducks were served for food, but peacocks, herons, cranes, storks, and even crows were esteemed choice viands. Fish was in general use, especially the eel,

which was held in particular estimation. Most dishes were prepared in spiced broths, which supplied the place of our modern soups, saffron and pepper being the chief seasoning ingredients. Among lighter articles of diet, omelets and honey are mentioned in 1303, with most of our common culinary vegetables and pot-herbs.

CHAPTER II.

Arts Relating to Architecture and Domestic Furniture.

SECTION I.—PUBLIC AND DOMESTIC ARCHITECTURE.

The Builder and Mason. The Carpenter. — After the destruction of the Western Roman Empire, centuries elapsed before architecture revived and flourished. The Goths and Vandals were totally unacquainted with the art of making bricks and mortar, and did not even use stone as a building material.

Brick-making, which thus fell into disuse, was not recommenced in Italy till after a very considerable period, though the mediæval ecclesiastical and palatial architecture of that country exhibits many fine specimens of brickwork. The wall tiles, introduced by the Romans, continued to be employed in England till rubble work was superseded by regular masonry about the time of the Norman Conquest. In the Low Countries the scarcity of suitable building-stone led, at an early period, to the extensive use of brick, not only for houses, but for ecclesiastical buildings.

The most ancient chapels and churches erected by the Goths and Vandals were composed of wood, as an example of which we have the first church in Strasburg, on whose site the present cathedral now stands; and both in Ireland and Britain there was a national prejudice in favour of the custom of employing timber to construct their religious edifices. The private dwellings of the same period seem to have been rude and miserable huts of clay and rafters, thatched with leaves and straw. The earliest stone buildings were the palaces of the princes and nobles, and the churches and monasteries of the monks. After the

tenth century towns began to increase in number and importance, and numerous fortresses were built on hills and rocky eminences. The prevalence of feudal aggressive wars, however, kept the people in a state of discouragement and alarm, and rendered both life and property insecure. Every isolated dwelling, therefore, was necessarily built for defence, as well as for domestic shelter and comfort, and the towns themselves were surrounded with walls, towers, and moats. The streets continued to be for many centuries narrow, crooked, and unpaved, and the houses were without chimneys, the smoke escaping by the door, or through apertures in the walls or roof. Chimneys were first erected in Italy and Germany about 1347, and in 1368 the streets of Nürnberg were paved, this being the first town in Germany where this was done.

So early as the time of Constantine, the art of constructing vaulted stone roofs seems to have been on the decline, and the roofs of the early Christian churches were of wood. In the sixth century was erected the flat dome of St. Sophia at Constantinople, with a diameter of 115 feet. Soon afterwards was built the Church of St. Vitalis at Ravenna, which has a hemispherical dome fifty-four feet in diameter. This is the first example of the re-introduction of dome-vaulting into Italy after the decline of Roman art. The dome was constructed of earthenware, pumice, and stone, and consequently no difficulties occurred in preparing the work. After this groined vaults of small span became very common, although the nave roofs of the Italian churches continued to be constructed of wood, with flat ceilings, until the thirteenth century, when the pointed style was first introduced into Italy.

The Gothic style of architecture is a distinguishing feature of the later centuries of the mediæval period; its pointed arches and its soaring pinnacles more nearly accorded with the loftier aspirations of the era. The walls were rendered agreeable to the eye by being covered with

architectural ornamentation, and light was admitted by numerous apertures. This produced a charming contrast with the grand solid masonry which was everywhere visible. From the thirteenth century, churches begun in the Roman style were usually finished in the Gothic or German. Among those whose architecture changed in style during their erection may be mentioned the Church of St. Gereon's at Cologne (1212—1227), Magdeburg Cathedral (1211), the Liebfrau Church, at Triers (1227—1244), the Elizabeth Church, in Nürnberg (1235—1283), and, above all, the Cathedral at Cologne (1248), in which the German style of architecture shone out most nobly and perfectly. There are other architectural memorials of this period deserving notice, as Strasburg Cathedral (1275), the Church of St. Catherine, at Oppenheim (1262—1317), the Cathedrals of Freiberg, in the Bresgau (1300), Ratisbon (1275), St. Stephen's, in Vienna (1359), Prague (1343), Ulm (1377), and the Frauen Church at Nürnberg (1355). Some of these buildings were constructed on so vast a scale that they were sources of employment for generations of masons, and were left even at last in an imperfect and unfinished state. A notable example is the Cathedral of Cologne just alluded to. It is 480 feet in length and 180 feet broad, and the choir is 200 feet high. The nave has 100 pillars, which are placed in four rows; and the towers, which have never yet been completed, were to have been more than 500 feet high. In these edifices every available space was filled with ornamentation composed of fantastic figures of plants, animals, and men. There were statues also, and reliefs, which, especially at the portals, often contained the whole history of the Christian faith, and were not unfrequently masterpieces in design and execution. In Italy, England, and France, as well as in Germany, arose Christian temples as grand as the temples of ancient Egypt, Greece, and Rome, and more sublime in their associations. Notwithstanding the magnificence and skill displayed in

these erections, the history of the class—which must have been an extensive one—by whom they were reared, is at this period unhappily enveloped in great obscurity. The names of only a few distinguished architects and masons have been preserved to us, the rest having been entirely forgotten. Gebhard was the architect of the cathedral of Cologne (1218). Erwin of Steinbach, architect of Strasburg Cathedral, died in 1318; and Johann Hülz completed the work in 1449. Anton Pilgram finished the Cathedral of Vienna (1423). The names of those masons who were distinguished in the higher branches of their art are Erwin's daughter, Sabina of Steinbach, and Sebald Schoner, of Nürnberg (1355); in more recent times Adam Kraft (1507), Tilman Riemen-schneider, of Wurzburg, and Nicholas Serch (1513). As in Greece, so in mediæval Germany, no distinction was made as to appellation between the most accomplished architect and the humblest labourer, all were alike called stonemasons.

Towards the close of the Middle Ages the beautiful simplicity of Gothic architecture began to deteriorate, until it became lost in arbitrary decorations and tasteless displays of fancy. Although the Pointed style attained to considerable perfection in Italy, yet the round forms of the Roman style were never entirely superseded. A new style now appeared, called the "*Renaissance*," a revival of the old Roman classical school. Traces of this are observable as early as the middle of the fourteenth century; but the abandonment of the principles of the ribbed vault, and the revival of the solid vaulting with elliptical gróins, the true *Renaissance*, dates from the time of Brunelleschi, who, in 1417, commenced the erection of the celebrated cupola of the Duomo at Florence, which was nearly completed at his death, in 1444.

The enormous Church of St. Peter at Rome, the Church of the Assumption at Moscow, and numerous palaces, not only in Italy, but in France and Spain, were built in this

style, which rapidly spread through the whole of Northern Europe. Here, however, a deviation from the original became so apparent that in the luxurious buildings of France the result assumed an aspect of utter incongruity.

As late as the thirteenth and fourteenth centuries, the majority of the houses in towns were of wood, and their roofs of shingle or of thatch, as in Vienna, Chemnitz, and Zurich. This continued to be the case even in the fifteenth century in Augsburg, Milan, Piacenza, Modena, Padua, and Bologna, and accounts for the fire regulations and building laws of a period which, as recorded in old documents and chronicles, was remarkable for numerous conflagrations. In the fourteenth and fifteenth centuries a number of fine private dwellings were reared in Nürnberg, Augsburg, and Zurich, increasing greatly the beauty of the cities. In 1491 an immense fire reduced nearly the whole of Dresden to ashes. Towards the close of the fifteenth century, as some protection from such disasters, a regulation was made as to corner houses, which were ordered to be built entirely of stone, and to be completely roofed with tiles. It was also enacted that all houses should have at least one storey of this material, and that if the proprietor was unable to build in this way he might only erect low buildings and stables of clay. Country dwellings belonging to the poorer classes were still in a rude state in the sixteenth century, and are described as "built of mud and wood, placed upon the ground, and covered with straw."

Most houses in mediæval times were built high and narrow, with steep pointed roofs. The rooms usually faced the street, so that in case of attack the enemy could be successfully assailed from the upper portions. These houses admitted very little light, owing to their height and the narrowness of the roads. The entrance-hall, from which winding stairs led to the upper storeys, was so wide that a loaded wagon could have passed through without difficulty. The staircase also opened up into another large hall or landing,

from which the different apartments were entered. The last flight of steps led to the upper storey, not unfrequently two or three times higher than the others; and on the summit of the gable a weathercock was displayed. Weather-vanes had appeared on the churches in the tenth century, and in the twelfth their further use was restricted to the nobility; they were now, however, allowed on the dwellings of the people. Tall chimneys were required by these lofty buildings. They had already been introduced in the fourteenth century at Rome, where they were erected, by order of Francesco de Carrara, in 1368, but they did not come into general use until much later; in France, for instance, not until the middle of the seventeenth century.

The carpenters of the Middle Ages, notwithstanding the magnitude of their works, and their skill and ingenuity, have left us no record either of the principles or the productions of their art. We do not know how they acquired that proficiency in mechanical and mathematical knowledge which was absolutely necessary to enable them to erect the enormous timber-works requisite in the great cathedrals. There were, as far as we can learn, no mathematicians, save among the Arabians, until the close of the Middle Ages, when the names of George Purbach and Johann Müller appear. The use, however, of both mathematical and mechanical instruments extends far back into the Middle Ages. That the carpenters of this period were in bondage, like the other craftsmen, is proved by the town law of Strasburg, A.D. 982, which rendered compulsory the performance of certain services every Monday morning, for the benefit of the bishop, to whom we shall frequently have to refer, without fee or any kind of compensation whatever. In 1368 a carpenters' gild is mentioned, among others, as having established itself in Augsburg.

SECTION II.—HOUSE FURNISHINGS AND REQUISITES.

The Joiner and Cabinet-maker.—The furniture of houses, castles, and even palaces, in early mediæval times, was rough and remarkably simple, excepting for the occasional use of tapestry or hangings. A rich man's home was much the same as that of many a cottager in the present day. The floor was made of stone or beaten clay, covered with rushes or straw, and only on festive occasions with carpet. The walls of the rooms were boarded; and at a man's height shelves were fixed, on which pitchers, glasses, and other vessels could be placed. Benches stood around the walls, whilst the chairs, stools, and tables, such as they were, consisted merely of large, long, heavy boards, supported either on four legs or on trestles. The windows were unglazed, and a thin piece of canvas, stretched over a lattice, formed a slight protection from the wind and rain. Chimneys, as already noticed, were not known. In such rooms, and on such seats, the old knights appeared at the banquets and carousals, females being present only to fill their cups and drinking-horns. Special apartments, furnished with suitable chests and boxes, were employed for the preservation of articles of clothing, ornaments, and other property. In the sleeping-rooms the beds were very high, a seat always standing before them.

The introduction of Gothic architecture in the thirteenth century breathed new life into handicraft in wood-work, and all articles of household furniture were gradually made in a more artistic fashion. From the relics of those times still existing, it is evident that joiners' and cabinet-makers' work first found expression in the benches of choirs, and the altars of cathedrals. We adduce, as early examples in ecclesiastical appurtenances, the altar of St. John's Chapel of Cologne, that in the Barfusskirche at Erfurt, and the benches in the Fuggerischen choir in the Church of St. Anna in

Augsburg. Upper Germany and Swabia are particularly rich in such productions of the joiner's art. In the wainscotings and ceilings of contemporary private dwellings there are similar indications of this sort of woodwork, in which the workmen stepped at once into both joining and cabinet-making, executing elaborate carvings in the Gothic style; and thus both these crafts participated in the spirit of advancement which so strongly pervaded that period of history. It must, however, be borne in mind that all wood-work was for a long time done solely by carpenters, and no separate mention is made of joiners and cabinetmakers throughout the Middle Ages, although these two branches of handicraft ultimately became fully defined and established.

The Potter.—The rude pottery of the Northern tribes was entirely superseded by that of the Romans, which spread through the countries on the banks of the Rhine and the Danube.* The potter's wheel was first used by the Germans in the seventh century. The vessels they moulded were baked in a fire, and had a hard ringing sound.

The Arabs were perfect masters of the art of pottery. Their vases and amphoræ are of a kind of terra-cotta; some are glazed, and some are of a soft, porous, biscuit-ware. No nation has exhibited so thorough a knowledge of the art of decorating with cheap materials as they; and the remains of their mosaic ornamentation, made of common clay, and glazed with varied colours, surpass anything else of the kind executed. The glazes they employed were of lead and tin. The Moorish ware was first introduced into Majorca, and thence, in 1115, it spread over Italy, under the name derived from that island, "Majolica." With it went the art of making encaustic tiles.

Terra-cotta works of an architectural character are con-

* The Romans manufactured a red lustrous ware on the banks of the Rhine, where, in several localities, Roman pottery and kilns have been found.

stantly met with in buildings erected in Italy between the twelfth and thirteenth centuries. Italy, profiting by her knowledge of the ceramic art acquired from the Moors, continued to be the chief seat of the manufacture of mediæval pottery. Majolica ware was extensively made, and the terra-cotta figures and bas-reliefs, covered with a stanniferous glaze, produced by Luca della Robbia, became celebrated. He also manufactured enamelled tiles which were used in the church at Pisa, about 1415—1420. In the fourteenth century, we find beautifully fashioned specimens of Dutch tiles, and also chimney tops. The advanced state of the potter's art in the fifteenth century is attested by exquisitely-made wine and beer pitchers, adorned with plastic ornaments, coloured glazing, and gildings. Housewives were well supplied with every variety, not only of earthenware, but of metallic vessels. Some of them, which were made even from the precious metals, were artistically wrought, and very highly valued. From old chronicles we learn that the culinary art, gradually losing its previous simplicity, became, in the fourteenth and fifteenth centuries, sumptuous and luxurious. The viands were served up in dishes which were regulated in material and design according to the wealth and taste of the owners. Nevertheless, knives were not laid to every guest, and forks and spoons were special curiosities.

The Glazier and Glass-painter.—Although in the severe climate of the North latticed windows were not a sufficient protection, it was long before the use of glass became in any way common. As usual, we find the first improvements showing themselves in ecclesiastical structures. We learn that the Frankish king Childebert (511 — 558) adorned a church with glass windows, through which a glorious light streamed. The effect as described could only have been produced by coloured windows, similar to those in the Church of St. Sophia at Constantinople (527—565). During the Middle Ages, abbeys and monas-

teries were regularly provided with such windows. Among them may be mentioned York Minster, built by St. Wilfred, and St. Peter's at Rome, by Pope Leo III. In Germany the coloured glass manufacture was carried forward to a high state of perfection, pieces of different hues being combined, as in mosaic work, to produce pictorial representations. Thus arose glass-painting, the first trace of which is met with in the monastery at Tegernsee, in Bavaria (983 — 1000). A letter of the abbot to Count Arnold is still extant in which he thanks him for providing such ornaments of decoration for the church. Houses for glass-painting were at this time also established at Tegernsee, whence other cloisters drew their supplies. Glass factories appeared at Hildesheim, 1022—1039, and a century later at St. Denis, in France. This art spread rapidly throughout Europe on the substitution of Gothic for Roman architecture, a fresh impetus being given to the staining of glass by the fact that the high pointed windows of the later style afforded much more scope for the development of colouring and ornamentation.

Although cathedrals and churches thus received ample light through windows of glass, both painted and plain, yet a thick gloom continued to pervade the apartments of the people, and for a long time there were no glass windows in villages, towns, or fortresses. It is supposed that even the castles and palaces of Charlemagne and other German princes were without glass windows. Oiled paper, linen, horn, and any other substance admitting a moderate amount of light, and excluding the wind and rain, were probably used to enhance the comfort of dwelling-houses. Windows of glass were introduced into England in 1180, some of the royal palaces and churches being then provided with them. In the next century cut glass is mentioned as an article of traffic conveyed up the Danube on which duty was levied. Albertus Magnus (1205—1280), Roger Bacon (1214—1296), and others speak of glass as being purified and deprived of

colour by manganese; the minnesingers extol its transparency and hardness, and speak of lamps, glass rings, and vessels of glass for the altar. We have also mention made of a parrot composed of glass, in a cage manufactured of the same material. Glass mirrors overlaid at the back with lead, are first mentioned in 1279, by Johannes Peccan, an English Franciscan monk, who taught at Oxford, Paris, and Rome. The first house for the manufacture of white glass in France was established by Philip VI., in 1330. In 1363 a corporation of glaziers is met with at Augsburg, and in 1373 one of looking-glass makers at Nürnberg. About this time white glass was made in Bohemia, as is proved by remnants still existing in Prague Cathedral and in Karlstein Castle. The use of glass, however, was still very limited, for the Senate House of Zurich, built in 1402, had cloth windows during the greater part of that century; but fifty years later Æneas Sylvius could boast that half the houses of Vienna had glass windows, and at about the same time window-glass is said to have been manufactured in England.

Cleansing and Lighting.—Soap and candles are essential requisites in domestic economy. History informs us that baths were much used during the Middle Ages. Whilst the thorough cleansing of the body was regarded by the ancients as a duty, and a mark of honour to the gods, so also in the Middle Ages a very similar belief prevailed amongst the people, who considered cleanliness of person as a matter of primary importance. Every village had its bath-house, many of the larger dwellings a bath-room, and in smaller houses there was at least a tub devoted to this purpose. The offer of the bath to a guest was considered a mark of hospitality. We are told in the book of Wigamur, that the hero was conducted to a room containing a stone bath, into which both hot and cold water flowed. Two attendants rubbed and shampooed him with both hands, after which they covered him with *badlach*, and saw him to his couch. In shampooing, water was poured on the whole head, then

unguents were rubbed in, after which the hair was cut, arranged, and combed. Soap was used during the Middle Ages, but very little is known as to its mode of manufacture. The Arabs are our only witnesses to its existence, for they mention the Gallic and German soaps as being used in both washing and medicine. The washing of clothing in Germany, as in ancient Greece, was conducted by women. Queens are said to have occasionally employed their time thus, and to have thought it no disgrace. In one of the books of the younger Edda, a quarrel is described as having broken out between Brynhild and Godrum in the veil-washing; and in another poem we read how a frightful death overtook Schwanhild, the beautiful wife of Jarmunrah, the Gothic king, while she was seated at the veil-bleaching.

For a long time the houses, and even the palaces and fortresses, throughout Europe, were but poorly lighted after sunset. Most dwellings were illuminated by brands or torches of pine-wood, reeds, and flambeaux, either placed on the wall or held by servants. The fire was in a pit placed in the middle of the room; and while the household slept this pit was covered with an open trapboard. In later periods of the Middle Ages, clay lamps, fed with oil, were brought into almost universal use. As early as the tenth century there were mills provided with stamping apparatus for obtaining the oil, but these could only be worked in summer time. A poem belonging to the fourteenth century tells us that crowns, upon which lights were placed, hung in the saloons, and that small wax tapers were fixed along the walls. The latter had been used in churches from the time of their erection, and were considered, even by princes, as extremely costly. Tallow-candles, candlesticks, and snuffers appear first to have become common in the fifteenth century, especially in towns, and are mentioned by Hans Sachs as among the necessary domestic utensils. In England, in the old Saxon time, the only candle used was a lump of fat with a wick in the middle, placed

upon a piece of pointed wood, called a "condel-sticca" or "candel-staef."

The tallow-chandler's trade is mentioned as early as the reign of Edward I. In the thirteenth century, when late hours had become more fashionable, cotton and thread were substituted for rushes and reeds, and the fat underwent some refining process. "By the ancient laws of Wales, the candle-bearer to royalty was allowed a piece of candle as long as the breadth of his hand, and was entitled to the fragments, and enjoyed the delectable privilege of claiming all the tops, on condition that he bit them off." *

The Cooper.—The cooper's art is one which originated in mediæval times, and is supposed to have been invented by the wine-growers of Italy. It was unknown to the inhabitants of ancient Egypt, Greece, and Rome, whose wine vessels, as we have seen, were made of clay, though leathern bottles were used for some purposes.

We have little information concerning coopers in the North until the time of Charlemagne, who ordered that good *barridos*, bound with hoops, should be sent to his palace and farms. In the latter part of the Middle Ages, the articles of cooperage were very numerous. The butt was small enough to be carried on the back, but the barrel (*bottich*) was very large. Besides the butt and barrel, there were smaller vessels for hand use, called by various names, indicative of the purposes to which they were applied. Among the Germans we meet with the *scheffel*, a corn measure; the *butterich*, a small barrel, containing from three to six measures; the *stuckfass*, a large cask or butt; and the *fuder*. The *fuder*, of a very ancient date, appears to have been so large that it was necessary to convey it from place to place on a carriage. The wood for staves and hoops was brought to Germany from the

* "Our English Home, its Early History and Progress." Second edition, 1861, p. 92.

Northern sea-ports by ships belonging to the Hanseatic League. The trade is first mentioned as existing at Strasburg in 982. The coopers of that city were compelled to furnish the wood for their casks or tubs at their own expense when any work was to be done in the bishop's palace. We are told that the same craft existed in the monastery at Weihenstephan, in 1146, under the appellation of "*büttner*," and in Basle, in 1248. In this latter case, however, the men were united in the same gild with builders, plasterers, carpenters, and coach-builders. In 1271 the Bishop of Basle formed with this gild a treaty of alliance and protection, from which it appears that coopers were already separated into two divisions, viz., makers of small and large vessels, or tub and barrel manufacturers. The statutes of the Coopers' Association in Hamburg, Weismar, Rostock, Stralsund, and Griefswald, of the year 1321, give us information about the craft, as also an agreement made between the coopers and citizens of Vienna (1340), with reference to the subject of leaky casks. In 1372 there were coopers at Zittau, in Saxony, and peculiar inlayers, gaugers of the work, in Nürnberg in 1397. Towards the close of the Middle Ages, festivities and processions, with hoop-dances, were annually held by the craft, and were kept up for many years afterwards at Munich, Breslau, Zittau, and Erfurt.

The Ropemaker.—We shall conclude this section with a few words on the ropemaker, but the shipbuilder's art will be treated of under the Modern Period.

In mediæval Europe, willows, reeds, rushes, and leathern thongs were for a long time used in place of ropes. In the ninth century the Finns were obliged to render to the Norwegians a tributary supply of ships' cables, made from the skins of the seal and walrus. Hemp was, however, produced at an early period in Germany. It is named among the plants which Charlemagne wished to have grown on his farms. It was especially cultivated around Augsburg, in Swabia, in the time of the Hohenstaufens, and oakum,

hemp, tow, and sailcloth were carried to the West by the Hanse vessels.

Rope-making must have been largely carried on during the middle ages, although the craft is not mentioned. The extensive navigation of this period in the Northern and Baltic Seas, its further progress during the time of the Crusades, and the scaffolding erected in the construction of the great cathedrals, &c., point to a large demand for cordage. The bells, too, which began to be hung in the high towers of the churches, were put in motion with ropes, and the grounds devoted to tournaments were marked out by their means. There can, indeed, be nothing splendid or beautiful in works of art without the co-operation of one or other of the humbler branches of industry.

CHAPTER III.

ARTS RELATING TO WEARING APPAREL.

SECTION I.—THE TEXTILE INDUSTRIES.

Woollen.—During mediæval times, as in antiquity, spinning and weaving continued to be domestic occupations. The most exalted lady was no more exempt than the lowliest bondwoman from a form of labour imposed by the sentiment of the age. Charlemagne commanded that "the women, who on account of our occupations are our servants, shall look after the wool and linen, and the making of our jerkins and coats." To these household avocations was added that of knitting, in which remarkable skill was displayed. The Emperor established upon his various estates spinning schools, where every description of labour connected with the woollen manufacture was practised. Bondwomen, working under superintendents, spun the yarn by means of the distaff and spindle, wove cloths, chiefly woollen and linen, and made them up into articles of clothing.

A surer though less imperious influence was making a knowledge of the textile art the common possession of the states of Europe. It was one of the vital principles of monachism that every religious retreat should as far as possible be self-supporting. The monks were artisans and cultivators of the soil, and to them we owe the preservation of the industrial arts, quite as much as of learning, throughout the dark ages. Each monastery was a luminous point, whence the light of civilisation radiated into the darkness around. As early as the ninth century, the fullers and tailors of the monastery on Lake Constance taught the

arts of spinning and weaving and of making woollen garments. The linen surplices made in the cloisters at Reichenbach were of so fine a texture that, by a decree issued A.D. 1070, the privilege was conferred upon the weavers of supplying the sacerdotal wants of Rome. In the twelfth century the institutions at Maulbronn and Senkendorf were notable for their large flocks, after which time we find the weaving of linen and woollens taking deep root in the German States. No other art was so productive of wealth; minor cities grew large and prosperous, and the position of the craftsmen became incompatible with serfdom. In various ways the workmen achieved their freedom as citizens, and eventually outrivalled princes in dignity and opulence.

Earl Baldwin, of Flanders, about the middle of the tenth century, induced weavers from Ratisbon to settle in his dominions. His foresight was rewarded by the growth of a textile industry which flourished for centuries. Coloured and figured fabrics, and others known as "*barracon*," gained wide and lasting fame, and Flemish weavers became so skilful as to warrant the supposition that a peculiar gift had been bestowed upon them by Nature. A cloth-market arose in 1350 at Middleburg, on the Island of Walcheren. No less than 50,000 citizens of Brussels were at one time dependent upon textile manufactures, and of the population of Ghent 40,000 are said to have been weavers. The Northern Netherlands, comprehended under the general name of Friesland, also obtained great celebrity in cloth-weaving during the Middle Ages. Thin white and coloured mantles were highly esteemed, and were a customary gift from the Franconian kings to the courtiers whom they wished to honour. Germany, during the twelfth, thirteenth, and fourteenth centuries, was a most flourishing seat of the textile industries, and eventually attained the highest rank among the Continental states for the cloth manufacture: a large portion of the wool used was imported from England. Even from the time of the Roman occupation English wool

had been prized for its quality of fibre, and England was supplied with manufactured cloths in exchange for wool. Cloths were also sent to Italy; and by way of the Rhine, Cologne, Ratisbon, Vienna, and the Danube, they reached the Byzantine Empire. Frieslandic mantles, black and white, were worn by the various orders of knights during the Crusades, and were forwarded in large numbers to Syria and the Holy Land. Some of these knights were merchants as well as soldiers, and possessed their own cloth-halls at Dantzig, Elbing, and Thorn.

Woollen Manufacture in Great Britain.—England, as a wool-producing country, could not wholly neglect the arts of spinning and weaving. The use of the distaff and spindle was common in very early times, but only inferior cloths were made. From an allusion to weaving in one of the homilies of Aldhelm, Bishop of Sherborne, it appears that the art must have made considerable progress during the Heptarchy. He compares a righteous character to a web "woven by shuttles, filled with threads of purple and other colours, flying from side to side, and forming a variety of figures and patterns in different compartments with admirable art." The mother of Alfred was skilful in spinning, and taught the art to her daughters. It is also remarked of Edward the Elder that "he sette his sons to scole, and his daughters he sette to wool-werke." It was not until the Conquest that spinning and weaving became approximately national, as distinguished from household industries; and spinster is still the legal designation of unmarried English women.

The founders of the manufacture of fine woollens were Flemings, who, driven by an encroachment of the sea from their own country, sought an asylum in England during the reign of William the Conqueror. They received protection from the Queen, who was a native of their country, and settled first at Carlisle. Not being able to conciliate the people around them, they were subsequently

removed into Pembrokeshire, where soon after their ability to wield the sword against the turbulent Welsh was regarded by Henry I. with as much favour as their skill in handling the shuttle. It is said that the Firbolgs, the ancestors of the Flemings, introduced the woollen manufacture into Ireland, and with it the use of the *lagun*, or mantle. Henry II. took great interest in the woollen trade. He established the "Cloth Fair," in the churchyard of the Priory of St. Bartholomew—a spot which still retains its name, and in some degree its character, as a cloth mart.

The textile art had now become of so much importance that corporations or gilds for its encouragement were established in London and many other places. Various towns paid fines to the King for the exclusive privilege of making cloth. Amongst these favoured places, London and Winchester ranked foremost. To London was accorded the sole right of exporting woollen cloths, in the exercise of which clandestine attempts at exportation were not unfrequently frustrated by seizures on the part of the City authorities. These privileges were accompanied with many meddlesome and vexatious enactments, interfering with the personal liberty of the weavers, and with the free course of trade. The domestic life of the weavers, the width and the quantity of the cloth to be produced, and the price at which it was to be sold, were all regulated by law. A curious decree of Richard I. enacts that, "No merchant shall stretch before his shop a red or black cloth, or anything by which the choice of the buyer is frequently deceived." It is evident that English cloths were still inferior to the Flemish, for, in order to enforce the wearing of home-made goods, a law, in 1261, prohibited both the importation of spun materials and the exportation of wool.

Edward III. revived the woollen industry, when it had been long checked by the disordered state of the kingdom. He showed his appreciation of fine Flemish cloths by wearing them himself, but such permission was in nowise

granted to his subjects. He encouraged Flemings to settle in England, in order to improve the home manufacture. Two weavers from Brabant settled at York, in 1331, where they made woollens, the King remarking of them that they might prove of great benefit to himself and to his subjects. One of the most notable of the Flemish immigrants during this reign was John Kemp, who, with a body of dyers and fullers, founded in Westmoreland the manufacture of the celebrated "Kendal green," referred to by Shakespeare in the play of "Henry IV." It was the policy of the King to disperse the foreign weavers through the country, so that their art might spread, while, at the same time, combinations amongst them would be rendered difficult.

In Fuller's "Church History," a list is given of the places where the foreign weavers settled. Woollen fustians were made at Norwich, baizes at Sudbury, broadcloths in Kent, kerseys in Devon, friezes in Wales, fine cloths in Worcestershire, Gloucestershire, Hampshire, Sussex, and Berks, coarse cloths in the West Riding of Yorkshire, and serges at Colchester and Taunton. This old divine states that the King gave the name of Web to a Dutch weaver of Gloucestershire; and likewise refers to the abundance of fuller's earth as an indication that cloth-making was meant to be a national employment.

Worsted stuffs received their name from the village of Worsted, in Norfolk, where they were first fabricated. A patent, in 1313, confirmed to Norwich and its vicinity this division of manufacturing industry, which has flourished there for nearly five centuries. The Irish woollen goods manufactured during the fourteenth century were of such a quality as to command a considerable sale on the Continent and in England. The fine, soft, scarlet woollen fabric called "serge" was prized in Spain for its texture and colour, and was worn by the monarch and grandees of that country.

English cloths, at the outset, were sent to be fulled and dyed in the Netherlands. This practice was eventually

discontinued, and towards the end of the fourteenth century they were dyed in England scarlet, russet and black, and, in some instances, sent as presents to influential French nobles. The legislation affecting the woollen trade was inconsistent. The consequence of putting an embargo on the shipment of English wools was to fill the home market with more than could be absorbed by the native manufacturers; upon this the value necessarily fell so seriously that the renewal of the right of export became a necessity. English caprice in these matters, as well as the great expansion of foreign industry, forced the Continental agriculturists to improve their breed of sheep, and to depend less upon the fine-woolled produce of England.

The Cloth-workers.—The pre-eminence which weaving took amongst the manufactures of the Middle Ages, and the opulence of the industrial burghers, originated great social changes. The weavers were always jealous of their rights. Their desire for municipal and industrial freedom increased with every concession which their wealth and power obtained or extorted from their martial rulers. Nowhere were there more valiant defenders of liberties, once obtained, than the gilds of cloth-workers. Even so early as the twelfth century, they were said to be "a bold, presumptuous people." In Ghent, Bruges, and Brussels, they formed an army in numbers, were trained as soldiers as well as artisans, and were foremost in every political conflict. Peter the Weaver, surnamed the King of Brussels, was knighted about the commencement of the fourteenth century, by William of Julich.

Linen.—In every country west of India—where the prevalence of the cotton plant rendered flax of little importance—the weaving of linen was an industry coeval with that of the weaving of wool. In some parts of Europe the cultivation of flax and the working of linen were of far more importance than the woollen manufacture. Flemish linen has been prized from the days of the Roman Empire. It was

early employed for saddlecloths, coverings for the head, coats of arms, and banners, and was often enriched with a golden thread.

The finest linens were those of the Netherlands and Westphalia. Their excellence commended them to all the Northern and Eastern markets. Bohemia, Saxony, and the Wendish States on the Baltic became eminent for their linen industry; but the circle of Swabia, in the south-west of Germany, outrivalled every other district in the extent of its manufacture and trade. Augsburg was distinguished for its linen-weaving even in the tenth century; but the fourteenth and fifteenth centuries were the times of chief prosperity among the German linen-weavers. Ulm and Augsburg grew exceedingly wealthy. All the adjacent country was devoted to the growth of flax and to the manipulation of the fibre. In the fourteenth century the craftsmen of Augsburg formed the second city gild. Many incidents associated with the colossal wealth of the Fuggers of this city have been described. Charles V., when viewing the treasury at Paris, is said to have exclaimed, "I know a linen-weaver in Augsburg who could buy all this with pure gold."

Linen-weaving has been practised in England from an unknown date; and the cultivation of flax and the manufacture of its fibre have prevailed in Ireland from a very early period. Linen was the universal article of clothing in the latter country at the time of the English Conquest, and its exportation is alluded to in a work published in 1437.

Cotton and Silk.—Fabrics of silk and cotton are of Oriental origin; and, although introduced amongst the textile industries of Europe, they never reached, during the Middle Ages, the dimensions and importance of staple manufactures. For 600 years after its introduction from China (A.D. 552), silk cultivation was isolated within the Byzantine Empire. The rearing of the worms and the weaving of the silk was practised in Sicily during the

twelfth, and in Italy during the thirteenth century, whence it was subsequently introduced into France and Spain.

Cotton was cultivated and manufactured by the Spanish Moors, and flourished as long as their power lasted. The mutual exclusiveness, however, of Moors and Christians prevented many reciprocal benefits from being interchanged; the artisans, consequently, found a trade with Africa and the East, rather than with the native Spaniards. The cotton-weavers of Barcelona, nevertheless, formed a gild in the thirteenth century, and gave their name to two of the streets of the city. The term "fustian," still so commonly used, had its origin in these times. It really means "substance," and is derived from the Spanish, *fustan.*

SECTION II.—DYEING.

After the fall of the Roman Empire, the art of dyeing was lost to Europe for several centuries, when it was re-introduced from the East. The murky atmosphere overhanging the West was not suggestive of the blending of bright colours, and, as commerce had perished for the time being, dye-stuffs were not imported. There were, however, a few native products, the use of which had been known from time immemorial. These were nearly limited to three —woad, weld, and madder. Woad is mentioned by Cæsar as the substance used by the Britons to stain their bodies with a blue colour. It grew wild in most parts of Europe, but particularly in Thuringia. Charlemagne ordered that madder should be cultivated upon his farms, and that, with woad and warentin, it should be supplied to the weaving-houses which he had established, so that dyeing might also be taught.

The details left to us of the dress of the Emperor and his courtiers prove that the use of varied colours had at length begun to spread. They wore blue, white, scarlet, and grey garments of Frisian make, the colour and texture

of which were sufficiently beautiful to render such articles worthy of presentation to the contemporary Caliph of Bagdad, the famous Haroun-al-Raschid. The breeches of the Emperor were of coloured linen, whilst bands of embroidered or figured check were wound round below the knees. The Frieslanders were the earliest to become distinguished for their skill in dyeing, and the distinction was long maintained, in close relationship with their pre-eminence in the antecedent arts of spinning and weaving. The dye-works of Harderwyk, still notable, are referred to in the twelfth century, especially for the production of blue and green colours. Flanders was early celebrated for scarlet cloths which were so much approved that the delivery of 1,000 ells, sufficient to clothe one hundred knights, was one of the stipulations made by Count Henry of Schwerin, in 1225, previous to the release from captivity of King Waldemar of Denmark. Scarlet cloths formed an important part of the presents which Henry the Lion, in his Crusades, offered to the Greek Emperor. Flemish dyers carried their art to Vienna, where it took root, the artificers always retaining the name of Flemings, by which designation they are referred to in 1208. Ratisbon and Augsburg were, however, the chief places where dyeing was pursued. Ratisbon was in repute for *barracan*, and for textures figured in colours. The dyers of Augsburg were incorporated in 1390 with the gild of weavers, a combination which appears to have given an impulse to both branches of industry.

Italy and Greece during the *Renaissance* Period outstripped most European States in dyeing, as well as in some other branches of industry. Silk tissues, dyed in the yarn, were woven both in the form of gauzes and of thick fabrics, and were printed either in single or combined colours. Venice stood high in the art of dyeing early in the thirteenth century. An order of dyers was instituted in this city in 1439, and the art had so far advanced that the dyers in black and the dyers in colours formed separate crafts.

Florence, likewise, became celebrated for its dye-works, not fewer than 200 such establishments being enumerated in this city at the beginning of the fourteenth century. While the uncultivated tastes of the people were captivated by the bright and the gaudy, a counteracting influence was at work in the self-mortifications, primarily imposed by the spirit of monachism upon the religious orders, but reflected generally upon the community at large. The worldly pleasure fostered by gay colours was denied as early as A.D. 785 to those who devoted themselves to religious retirement. A sombre garb was worn by the nuns, and coarse cowls by the friars, as the only befitting raiment for those who aimed at the crushing of natural instincts and the abnegation of self.

The Crusades mark an important epoch in the history of dyeing in Europe. The leaders, leavened with Oriental taste, introduced into their own lands the custom of wearing gay clothing, particularly of yellow and scarlet, striped or figured. The zealous but comparatively rude crusaders, nevertheless, could neither understand nor imitate the exquisite harmony which delighted the Arabs, or the felicity of design in which they excelled. Early in the fourteenth century red clothing lined with yellow was the fashion affected on holidays by the Genoese; while the Bolognese wore, as a mark of wealth and distinction, scarlet robes lined with green. The love of coarse and extravagant colours continued, intensity of hue rather than delicacy of shade being sought. Even so late as the fifteenth century, refinement of taste was so little cultivated that parti-coloured garments were worn, and others of the pattern of the chequers used on the chessboard. Similar bad taste was displayed in embroidery; an odd sleeve or one breast being richly worked, whilst the other was left plain. Nevertheless, the colours were permanent, and the weaving and embroidery of very high skill, since many of the robes and tapestries preserved from mediæval times are still fresh and bright, and of a fine texture. The dyer's art, therefore, had made great advance

before the Modern Period. Notwithstanding this, only the comparatively wealthy could command a variety. The production of clothing of any kind was very limited, according to modern ideas; and the poor had a struggle to obtain the humblest and coarsest textures of black or grey, and of these but a scanty supply.

Black was used for mourning during the Middle Ages, a custom still followed. As time advanced the general taste began to improve, and before the close of the fifteenth century gaudiness had given way to sobriety and simplicity, children only appearing in variegated attire.

Dye-stuffs.—Previously to the discovery of America, the dye-stuffs used in Europe were comparatively few in number, although added to from time to time by the progress of knowledge and invention. Red, scarlet, or crimson dye was obtained from peculiar oak-galls, called scarlet-berries, and the tree was named the scarlet oak (*quercus coccifera*). The galls were the produce of the puncture of an insect called kermes, and came principally from Spain. Brazil-wood was known before the discovery of America, and, from the abundance of a similar species of tree in South America, afterwards gave the name of Brazil to a vast region of that continent. This, together with red sanders-wood, was also used for red dyes. Orchella, too, produced a red extract, which received the name of "archil," a fleeting dye, but brilliant in colour.

Yellow dyes were extracted from fustic, safflower—from which rouge and China lake are also prepared—and saffron. Another yellow (*ozriffal*), from Spain, was so extensively used that the Catalans of Barcelona maintained special stores for its reception in the cities of Brussels and Frankfort-on-the-Maine.

Blue dyes were obtained from indigo as well as from woad. Indigo, originally from India, made its way, in spite of much opposition. A decree of the German Diet declared it to be a "pernicious, deceitful, and corrosive dye." In England,

also, laws were passed prohibiting its use, in consequence of the discouragement it gave to the native woad. This latter material was cultivated for export, to a large extent, in the country round Erfurt, which town, with several others, formed the commercial depôts of the trade, under the appellation of the "woad towns."

SECTION III.—THE TAILOR.

There was little variety in dress during the Middle Ages. Men usually wore close-fitting leggings, which, at first separate, were subsequently made into one garment, seated, and modified into the modern pantaloons or trousers. Over these leggings, a coat or tunic, derived from the Romans, was worn down to the knees. This coat was furnished with sleeves, and was fastened round the waist by a belt, the neck being left free. A mantle called the "*dalmatica*," or a simple cape, thrown over the tunic, with the frock or jacket fixed by a clasp or buckle to the right shoulder, completed the costume. Women of all ranks were dressed in a close-fitting body, with sleeves, over which a looser garment was drawn, with a kind of hood, serving partially to cover the face. This old Frankish mode of dress differed from that of the later period of the Roman Empire in its rudeness, scantiness, and gaudy colour, but in style it was much the same, and remained so for several centuries.

Tailors are incidentally mentioned amongst the Burgundians as early as the seventh century; and as towns began to grow into importance, tailoring came to be regarded as a regular handicraft. Amongst the monks this craft necessarily took a prominent place, and is enumerated in connection with the industries of the cloisters of Constance in the ninth century. Henry the Lion granted to the woollen-drapers of Hamburg, in 1152, a

charter, which is the oldest document referring to a tailors' gild. It is evident, from the use of the term woollen-draper, that tailors added to the use of the scissors and needle the business of buying and selling cloth; and to the present day they are accustomed to add "draper" to their trade description. Information concerning this industry is, from the establishments of the first gilds, sufficiently abundant. Tailors partook of the rising fortunes of handicraftsmen, shook themselves free from feudal servitude, rose to wealth and distinction, and shared in the new-born dignities of municipal independence. They appear to have been as turbulent as the weavers during this period of transition, and were valiant, both in procuring immunities and in maintaining their rights. The tailors of Basle, in 1260, obtained leave of Bishop Berthold to incorporate themselves into a brotherhood; those of Hoxter, in 1267, with the sanction of the burgomaster, founded a gild, which they placed under the tutelage of the Virgin Mary; those of Nürnberg are mentioned in the year 1360, and in 1378 their rights to a common share in the honours of the civil administration of the city were recognised by the burghers. The designation of "*mentelers*" was given to the craftsmen of Nürnberg. In Breslau the tailors for women's and men's clothes formed two distinct classes, as they do in Germany at the present day.

The rise of the tailor's art did not take the constant occupation of sewing out of the hands of women, and princesses did not disdain the work while surrounded by their women.

Tailors are identified solely with the cutters-out and makers-up of woollen clothing; but clothiers, working in linen, and in silk and embroidery, are spoken of repeatedly in the fourteenth century, and in Munich they were important enough to form a distinct fraternity. That the tailor's art was by no means so easy as in the present days of sewing by machinery may be gathered from the fact that

the needles used possessed no eyes, and the thimble, called a "fingerlinge," was made of leather. A great improvement in the manufacture was consequent upon the invention of wire-drawing, in 1360, and needles were then made with eyes. Metallic thimbles were also introduced at this time.

Princes and nobles, on state occasions, wore mantles of silk, and gorgeous gold and scarlet garments; and the robes used by Church dignitaries on sacred festivals were of the same costly character. The magnificence of these costumes was increased by borders of lace, fringe, and embroidery, the letters of a noble name being occasionally worked in for decorative purposes. The silks were either Oriental products or trophies of Venetian looms. Venice at this time stood pre-eminent for the fabrication of gold and purple stuffs, tinsel, satin, damask, inwrought with gold and silver figures, coloured velvets, white, yellow, and green, together with the still more favoured purple. Dresses were sumptuously lined with furs brought from Russia and Scandinavia, and up to the thirteenth century exhibited increasing splendour according to the rank of the wearer. Every class in society, from the lowest grade to the most elevated station, could be easily distinguished by the style and quality of its clothing; and this distinction of dress was maintained as long as the wealth and power of states remained exclusively in the hands of the nobles, and of particular royal families. With the fourteenth century, however, a change ensued. A natural emulation of lordly state was a sign of a growing opulence of the burghers. Unrestrained by the refining accessories of gentle birth, this desire for display ran to excess, and, for more than 200 years, profusion and extravagance, without taste, prevailed among them. A reaction set in amongst the polite, the learned, and the noble, whose attire became subdued and simple. A comfortable, full, and graceful robe took the place of the *dalmatica;* and the doublet, or tunic,

and trousers, properly so called, completed an unpretending costume. This great transformation was not accomplished without many efforts on the part of rulers still to maintain the dignity supposed to be afforded by distinctive dress.

Sumptuary Laws were enacted in a variety of cases, with the view of keeping the various ranks of society in their proper stations; and as the regulations materially influenced the labours of those who had to provide for the public wants, we must not omit to notice them. Silk was several times prohibited to burghers, who were also required to wear shorter mantles and sleeves than were adopted by the nobility. In like manner burghers' wives were obliged to curtail the length of their veils, so as not to run the risk of being mistaken for their superiors. Such interferences with taste and social habits were regarded as essential duties of government. They were carried to their most extravagant length at the Diet of Worms, in 1479, when a universal edict was issued decreeing the mode of dress for every order, without, however, being able to accomplish what was an impossible as well as an impolitic object. The frequent repetitions of such decrees proves their small effect. The rulers of France, Italy, and Germany, from the twelfth to the fifteenth centuries, repeatedly forbade to females the wearing of low bodies; and it is narrated of the Florentine women that they evaded these enactments with so much ingenuity that, while indulging more than ever their love of dress, they rendered it impossible for the strictest judges to convict them.

The sumptuary laws often placed tailors in a dilemma. They had to study the statute-book, as well as that of the fashions, and to choose between dissatisfying their customers and breaking the law. They were subject to penal inflictions for using either a material or a style not in accordance with the regulations for the class to which the customer belonged. In Ulm a sentence of banishment from the town for three

months, together with a fine of five florins, was passed upon offending tailors.

SECTION IV.—LEATHER-WORKERS AND FURRIERS.

Germany was in early times pre-eminently the country for the use of furs. So beautiful and rich were those used by the chiefs that they excited the cupidity of the Romans, who provoked a rebellion amongst the Frieslanders by attempting to levy a tribute of skins and furs. Central Europe was then covered with dense forests, which were the haunts of innumerable wild beasts and fur-clothed animals. The capture of these was the pursuit of the inhabitants, whilst the skins obtained constituted nearly their sole source of wealth. Amongst the large beasts were the auroch or bison, the common ox, the elk, the wild boar, the bear, and the wolf.

While furs were becoming fashionable in Italy, the Northern races were growing acquainted with the more convenient clothing made from woven textures. Furs, nevertheless, continued to maintain among them a high price as objects of demand. They formed the state attire of Courts, and were the favourite costume of the nobility and of Church dignitaries. The indigenous produce of Germany was at first solely relied upon, but the courtiers dressed in foreign furs. Charlemagne himself used exclusively sheep and otter skins, and laughed at his courtiers when their expensive dresses were ruined by the rain in hunting, while his simpler garb remained uninjured.

Knights wore clothes edged with fur over their armour. This was their distinctive dress, and it was only by an infringement of the privileges of the knightly order, against which the law provided, that any lower classes of citizens wore furs. Such infringements did, however, take place, for prohibitions were repeatedly issued in France, England, and Italy, against illegal indulgence in furs. Even so late

as 1497, an attempt was made in Germany to restrain this luxury. Citizens, who were not noble, were forbidden to use sable and ermine; and the only kinds which even the privileged might wear were duly specified. It was necessary to repeat this ordinance more than once in the following century. The Emperor Henry V. granted the privilege of wearing furs, as a special distinction, to the councillors of Bremen.

Furs never appear to have been indulged in at the Byzantine Court. The rich dresses, worn by the embassy sent in 1001 by the Emperor Otho III. to Constantinople, filled the Court with astonishment as well as admiration; and when Godfrey of Bouillon, about a century later, visited the Emperor Alexius, the gorgeous costumes displayed by him and his retinue excited similar feelings.

A curious record of the relative value of furs comes down to us from certain laws promulgated in the tenth century by a Welsh prince, who rated the skins of the ox, stag, fox, wolf, and otter, at the value of eight skins of the sheep or goat, while the skins of the small fur animals were much more costly. Thus a white weasel's skin was an equivalent for eleven sheep-skins, that of a marten was worth three ox-hides, and that of a beaver fifteen ox-hides.

Leather was in extensive and almost exclusive use among the Saxons and the early English while the woollen manufactures were as yet but little developed. Leather gloves, saddles and harness, belts, scabbards, and cases for shields, were German manufactures from an early date. Arising out of the great use of horses in war, leather riding-trousers were deemed requisite, and consisted at first of separate leggings, reaching down below the knee, but afterwards united by a piece of calf called "*bazan*" or "*becan*" around the hips. These trousers were confined by a strap running with the upper seam round the loins, the plan of suspension by braces not having then been devised. They

were worn by the order of knights at Marienburg as late as the fourteenth century.

Glove-making was a highly important branch of the leather-worker's art. Fur gloves were not unusual in the time of Charlemagne, and the monks wore coverings of sheep-skin on their hands in winter. Men's gloves, demanding strength rather than beauty, were made with a thumb only, the fingers being exposed, as is the case with what we now call mittens. Ladies' gloves were much more delicately fashioned, and were adorned at the back with pearls and precious stones, or with a single large jewel. Jewellery was also worn upon the fingers, over the glove. Gloves were often extended into gauntlets, reaching halfway up the arm, or even as high as the elbow.

Saddles and stirrups were not used by the old Germans, who, regarding such aids as unmanly, usually rode on the bare backs of their horses, and despised the Roman fashion. But before the close of the Middle Ages saddlers' work and the manufacture of riding-gear must have been brought to great perfection. A new system of warfare had been gradually established. Fighting was now almost entirely a conflict of horsemen, and totally dissimilar from the military evolutions of the ancient Greeks and Romans, who depended chiefly upon the strength of their infantry. The soldiers of Charlemagne consisted mainly of cavalry, and Henry I. ordered regular practice in horsemanship when he built towns and fortresses along the eastern frontier of Germany. The tenants-in-chief, in the twelfth and thirteenth centuries, nearly all performed military service on horseback, and were called "knights." The tournaments of the twelfth century were for the most part public trials of skill between horsemen armed with lances, who charged upon each other at a gallop from opposite points of the arena, the object of each being to remove his antagonist from the saddle. It is evident from history that the saddle was now fitted out with all possible splen-

dour and luxury. Pictorial representations of the times show the saddles to have had high backs and strong pommels, and to have been held in position by girths beneath the body of the animal, and by a broad strap across its breast. In tournaments the knights sat on a plain saddle, with common stirrups and straps. In a poem of the period, the following description of sumptuous riding-gear occurs, which serves to show the amount of care expended upon it: "In the tent lay a dark-red saddle, with its two bows ornamented with carved work. The saddle itself was bordered with gold, and overlaid with jewels. The bridle, also, which was edged with gold, had rings of the same material. Beautiful rings and bells hung from the broad bows, all of the same material. The stirrups were not of iron, copper, or brass, but of beaten gold, and the straps by which they were attached were of corresponding magnificence. Images of lions, dragons, or other imaginary animals were engraved upon them. The bridle was equally beautiful, the bit of silver, the girths of silk, and everything else of gold and jewels."

Among the leather-work of the Middle Ages, the girdle worn by ladies deserves to be noticed. This article was considered, in the thirteenth and fourteenth centuries, indispensable to female costume, being everywhere significant of the *gentlewoman*. It was usually a band of leather or silk, upon which glittered an abundance of gold and jewellery, and its ends were long and ornamented. Common girdles were united by merely passing one end through a hole and fastening it to the other. Richer girdles were provided with a costly ring and an aiguilette of beautifully-cut stone. These girdles were frequently twelve inches broad, and in the fourteenth century were adorned with bells and tinkling ornaments. Scissors, keys, and knives, and long pockets, embroidered and adorned with goldsmiths' work, were also commonly attached to them.

It is evident that an industry of such general importance

as that of the leather-workers and curriers must have played a prominent part in the development of municipal power and in adding to the wealth of towns. As early as 982 we find established by statute in Strasburg a corporation or gild of workers in leather and furs, comprising curriers, saddlers, shoemakers, glovers, and furriers. This combination formed one of the twelve associated handicrafts. The subdivision of labour into trades was not then carried to its present perfection; many of the shoemakers, indeed, had to prepare their own leather. At the time of the formation of this company feudal exactions were in full force. The bishop claimed from the craft everything in leather and furs necessary for his use and convenience. The furriers had to provide for his dress, and the curriers and glovers were required to furnish leather covers for the earthen vessels and candlesticks in use during his campaigns, or in his state travels. The saddlers likewise were bound to present suitable and sufficient masterpieces of their art for his service.

The bridles, saddles, scabbards, and sheaths for daggers made in Strasburg were everywhere esteemed. The industrious communities of the South Netherlands, particularly of Ghent and Namur, were famed for similar articles. Curriers carried on their handicraft in Augsburg in 1276; tanners are referred to in 1305 at Bremen, and in 1349 at Nürnberg. Vienna and Greece were early noted for excellent leather-work, and in the middle of the fourteenth century Hungarian straps with metal fastenings were in great demand.

Our information relative to the methods used in the Middle Ages for the transformation of skins into leather and for the preparation of furs is almost wholly inferential, since the writers of the period make only the briefest indirect allusions to the industry. Suppleness appears to have been imparted to leather by the application of oils and fats, especially seal-oil. The silence maintained with respect to

these processes implies that there was nothing new in them, and that the operations of tanning, from dressing and improving the hides with lime and oak-bark, to the preparation of leather fit for the saddler, shoemaker, and glover, as well as the implements used in the manufacture of the art, had been the same from time immemorial. The tawing of white leather and fine skins by means of alum and oil, or yolk of eggs, as contrasted with the tanning of hides, cannot be traced to any certain date, although practised in the Middle Ages in Italy and in Hungary. The skins of sheep, goats, and stags were prepared by this process, which eventually grew to importance in Augsburg and Nürnberg.

The first gild of furriers, as separate from tanners, was instituted at Magdeburg. While the Hanseatic League flourished, many beautiful furs were brought from Scandinavia and Russia. Of these foreign furs, those of the Russian sable and ermine were the most highly valued, and comprised, with those of the beaver, otter, marten, and shrew, a department of the trade called "fine work." The appellation "work" was given to all fur goods. Wolf, fox, lynx, badger, bear, and seal skins were common kinds. Furs of a better description were called "fine," "grey," "variegated," and "spotted." Grey work included the furs of the grey squirrel and of the domestic cat; variegated work comprised the skins of the marmot and brown squirrel; while spotted grey work was a mixture of the variegated and the grey types.

SECTION V.—THE SHOEMAKER.

Protective coverings for the feet were a necessity in the boundless forests, marshes, and moors of Northern Europe. Indubitable evidence is afforded of one kind of foot-covering —the rough sandals, or soles, with straps attached for a fastening. Shoes made of skins, with the wool or fur worn internally, were likewise in early use. Improvements took

place as the arts of refinement were gradually diffused. Luxury and display appeared at the Frankish Court, and silk shoes, enriched at the back and round the sole with jewels and pearls, were used for occasions of ceremony. For princes this was the ordinary style.

We have descriptions of soft leather shoes, and of red or violet shoes, extending as far as the knees. The Emperor Charlemagne wore the primitive covering of soles strapped to his feet, and half-boots extending in folds midway to the knees. This ancient Frankish costume lasted throughout the Crusades. Besides these forms of shoe, large and strong boots, called "hosen," protecting nearly the whole of the leg, like the modern waterproof jack-boots of excavators, grew into favour, from their admirable adaptation to the roughness of the climate and country.

The fashion in shoes, as well as in other parts of clothing, was quite altered after the Crusades. The straps, which had been in requisition to confine the sandals or shoes to the feet, were now dispensed with, and soft Cordovan leather, or sheep-skin, stained black, was made to fit closely around the foot. The Frankish mode disappeared. The age of extremes, which brought in grotesque shapes and gaudy colours in vestments, affected shoes also. They became long and pointed, the beaks of the shoes attaining by degrees the inordinate length of two feet, and encumbering the wearers to such an extent that fine gentlemen fastened the extreme ends to their knees by means of laces or of gold and silver chains. Small bells were also suspended to them, whose tinkling gave notice of the approach of people of consequence. Green, blue, or red were the colours preferred, and this extravagance in taste lasted for several generations. Even in battle the officers' boots were so long as to incommode them; and it is related that during the Battle of Sempach, in 1386, the knights were unable to get out of the stirrups until the points of their boots had been cut off. The fashion was interdicted in England, in 1467,

under the double penalty of twenty shillings fine, and of falling under the ban of the clergy. The great mistake of legislating for errors which can only be cured by the cultivation of purer tastes, was exemplified in this fashion of pointed toes. The anathemas of the Church and the penal edicts of the State succeeded, not in destroying the bad taste, but in diverting its direction. Length of toes being prohibited, extravagance in breadth was adopted, and broad-toed, diminutive-heeled shoes, likened to the claws of a bear, became the standard of beauty in coverings for the foot.

At a period scarcely later than the sixth century, the Burgundian laws recognised the shoemakers as a craft. Shoemaking was one of the industries promoted by Charlemagne. As with the spinners and weavers, so with the shoemakers, he formed establishments upon his farms for instruction in their art. The handicraftsmen have been variously known as shoe-workers, shoe-makers, shoe-weavers, shoe-masters, workers in bullock-skin, and cordwainers. The last-mentioned term is the name by which the London gild is still called. This designation was first used in 1150, and is derived from Cordova, in Spain, where the Moors for a long while prepared the Cordovan leather, of peculiar excellence for boots and shoes. It was afterwards successfully imitated by the Germans, but retained its name just as Morocco leather now does. Workers in bullock-skins were, as their appellation implies, those who used ox-hides for soles or calf for the upper leathers.

Shoemakers were among the first to rescue themselves from the thraldom of the lords of the soil. Their early municipal importance is attested by the fact that the oldest streets in many cities were named from them. Shoemakers, as we have seen, are on the Strasburg list of artisans in 982. In 1157 Archbishop Wichmann confirmed to the shoemakers of Magdeburg their ancient

honours, rights, and privileges, from which it is evident that the company must have been already flourishing. An ordinance of the Emperor Charles IV., in the fourteenth century, to the citizens of Frankfort, shows the eminence to which the master cordwainers of that city had attained, for they were required, as constituent members of the army, to provide a coat of mail, and to prove themselves possessed of property of the minimum value of thirty gulden. The rights of these gilds, as in other cases, were of a very exclusive character; but the cordwainers were subjected by the frequent sumptuary enactments to restrictions as irksome as they themselves imposed upon their trade. The law of England even took cognisance of the number of stitches to be used in a boot or shoe. The "shoe-servants," or workpeople, also, were not always disposed to submit to the discipline to which they were subjected, and gave their employers so much trouble that we find attempts were made by the Diet of Frankfort, in 1421, to remove these difficulties.

The rough wear to which the boots and shoes were exposed rendered the business of repairing of an importance hardly short of that of making, and in no long while the cordwainers made these divisions of their art separate and distinct, calling themselves respectively masters of new and of old work. The masters of old work were excluded as rigidly as foreigners from the manufacture or sale of shoes, while those of new work were similarly bound to decline all the profit arising from mending. In Britain, very generally, the *cardiners* formed a distinct gild from the *sutors*, or shoemakers, and the municipal records contain many references to the jealousies subsisting between them.

SECTION VI.—HAIR-DRESSING.

During the Middle Ages, the hair continued to be as greatly regarded as it had been among the ancients. The French kings, like the Roman emperors, were accustomed to wear it long, and artistically curled and dressed. Ladies wore their tresses hanging loosely over the shoulders, sometimes having the ends fastened with ribbons. At other times, their back hair was braided, intertwined with gold and silver threads and strings of pearls, and brought forward in plaits over the shoulders to be displayed in front. The rest was divided in the middle; curls fell down the sides and concealed the ears, and the whole was kept in order by a band or ring. A great variety of fashions of head-dress arose from time to time, amongst which was that of a ring worn low round the head, and connected from ear to ear by a broad cloth or band. In the "Nibelungen Lied," we read that garlands beautified the heads of the ladies, and that gold braids were interwoven in their hair or trimmed into their caps. In a poem of the same period, precious stones, arranged in small glittering edges, are spoken of as part of a lady's festive head-gear. At a later period, towards the beginning of the fifteenth century, the love of embellishment inherent in the female mind took the form of a taste for gold and silver leaves, and bands, chains, and buckles, of the same metals. Strings of pearls of great value, and other costly jewels were thought indispensable to complete a suitable head-dress. With these were worn occasionally garlands of pure gold, or wreaths set with diamonds and pearls. Elderly ladies wore lace caps inwrought with gold and pearls. While, however, gentlewomen with abundant means could thus gratify their taste for adornment, women in general only exposed the face to view, and concealed their hair and the rest of the head with a white veil, or with linen frontlets.

The appearance of the clergy during this period formed

a marked contrast with the rest of society. They had been forbidden, so early as the year 155, by Pope Anicetus, to wear their locks long. The tonsure had been compulsory for monks from the fourth century. Laymen, in the twelfth and thirteenth centuries, reached an extreme the opposite of monastic austerity. A red beard gave to the Emperor Frederick, in the middle of the twelfth century, the surname of Barbarossa; but at this period the beard was not so common as the moustache. In England considerable attention was paid to the hair, although after the Conquest beards were not fashionable until the thirteenth century. The vocations of the barber and the surgeon were united, under the designation of "barber-surgeon," the followers of which craft formed a gild in 1308, which was incorporated in 1462. In 1540, however, the union of the two professions was disturbed, and in 1745 dissolved.

It is evident that, whether the care was to shave the chin, or to keep it neat when a beard was in growth, the business connected with toilet operations and appurtenances must have been considerable. Many combs of the Middle Ages are preserved, but no record is to be found of comb-making as a distinct handicraft. Nevertheless, the elaborate work bestowed upon these instruments, especially when they were intended for the use of great personages, must have rendered them costly productions, for they were beautifully carved in ivory, and set with jewels and gold. The principal materials employed were ivory and wood, and the combs were set with either a single or a double edge of teeth. A jewelled comb formerly belonging to Henry I. is still preserved. An ivory one once used by the Abbess Hildegarde, who died in 1140, was long to be seen in the cloisters of Elbingen. It was cut with two rows of teeth, and was six and a half inches long by four and a half broad. A comb believed to have been Charlemagne's is yet to be seen at Osnabrück, and one of Hildegund's at Bamberg.

SECTION VII.—HATS AND CAPS.

In the earliest centuries of the Middle Ages, it was, as a rule, only in war that the head was covered. Except in the case of kings and princes, who wore the regal cap, adorned with a diadem or bedecked with feathers—an innovation from Asia, early adopted in the West—it was customary until the twelfth century to go bareheaded. It was not, indeed, until the approach of the fourteenth century that the fashion of covering the head was by any means common. Even the country people, whose style of loose hat traces its origin to a very remote period, only wore it when rendered necessary by the weather.

The use of hats became general on the increase of wealth and the extension of towns. When the burgher class grew important, they copied for their own wear the royal pointed hats. The abolition of serfdom spread the habit of covering the head, from which slaves had always been interdicted. The custom soon extended, and even the monks surmounted their hoods with conical caps. These tall cones were curtailed towards the beginning of the fifteenth century, and shorter hats, called "Bohemian balls," with the brims turning upwards, soon became the universal fashion. The nobles retaliated upon the peasantry for copying the aristocracy by adopting the loose head-gear of the countryman.

But little information is given of English hats in the Middle Ages. Caps of skins, with the furry side outermost, appear to have been adopted by the Saxons, and at a later date Chaucer describes the Flanders beaver hat of the canon, and also that of the ploughman. Hats proper were not made in England until 1510, and then the manufacturers were Spaniards.

In France hats were made by a Swiss, in 1404. When his country was thoroughly freed from the invader, Charles

VII. made his triumphal entry into Rouen, in 1449, wearing a beaver lined with red velvet and crested with rich plumes, from which time hats and caps began to take the place of chaperons and hoods.

The women of the Middle Ages wore bonnets, varied both in style and material, particularly during the fifteenth century. These answered the purpose of a head-dress, as well as of a protective covering. As depicted by the poets of the time, they must have appeared very imposing, being made of silk and velvet, and enriched and embroidered with feathers of the peacock. Some were towering, while others were broad, and constructed so as to cover the face.

Of hat-makers and their craft in these early days we have little or no knowledge. They do not seem to be referred to at all in an associated capacity.

CHAPTER IV.

ARTS RELATING TO MINING AND METALS.

SECTION I.—MINING.

Coal-mining.—Although mining in England was much neglected by the Saxons, they appear to have been acquainted with coal. The first notice of it for domestic purposes is in the "Saxon Chronicle"* (A.D. 852), in which the mineral is referred to under the term *græfa*, from the root *grafan*, "to dig." The Celtic term *glo* is also of early date: by the Irish, coal is still called *guell*, and by the Cornish, *kolon*. It is probable that the Romans used coal whilst resident on these shores, for in the large cinder-heaps of Yorkshire a number of their coins have been discovered. However this may be, it is nearly certain that it was extracted from its bed among the Welsh hills at a period quite as far back as that of the Anglo-Saxon kings.

The revival of mining was one of the industrial compensations conferred upon this country for its conquest by the Normans. By them the mining for metals was vigorously carried on, though from the little mention made of coal during our Norman period, it may reasonably be inferred that the value of this mineral had not as yet been appreciated. It is, however, referred to in the "Boldean Book," which is a sort of "Doomsday Book" of the county of Durham, compiled about 1183:—"The smith was to have twelve acres of land for doing the ironwork of the carts, and to raise his

* "Wulfred should each year deliver to the Minster sixty fother of wood, and twelve fother of coal (*græfa*), and six fother of fagots, and two tuns of pure ale, and two beasts fit for slaughter," &c.

own coal." It was not, however, until 1238 that the first collieries were established on the high grounds in the neighbourhood of Newcastle. In 1239 we have the earliest public recognition of coal as an article of commerce; and from the charter of Henry III. to the freemen of Newcastle-on-Tyne, we may date the foundation of our coal trade. In 1273 the use of coal in London was forbidden by royal proclamation. This prohibition seems, nevertheless, to have been disregarded, as a second was issued, directing that delinquents should be fined, and their furnaces and kilns destroyed.

Not many years after we find that coal was used in the royal palace. In 1380 the monks of Tynemouth Priory engaged themselves in mining speculations, and leased a colliery for £5 per annum. Soon after this a tax of 2d. per chaldron was put on sea-borne coal, and in 1421 an Act was passed still further to secure this tax. About this period frequent references to coal-produce occur, and it is probable that during the fourteenth and fifteenth centuries mining became general in most of the coal-fields of Britain.

Metalliferous Mining.—During the reigns of the Plantagenets, mining industry received a large share of attention, the mines of tin, copper, and lead being worked with comparative vigour. In the reign of King John, the tin-mines of Cornwall were farmed by the Jews. Old blocks, commonly called Jews'-tin, have been obtained from the district of St. Agnes, and rude furnaces have been discovered which are supposed to have been connected with them, although they may possibly have belonged to the times of the Phœnician trade with Britain. The earls of Cornwall derived a considerable part of their revenues from the produce of the tin-mines. The Spanish mines, which had formerly supplied the Romans with large quantities of tin, were in the possession of the Moors, and, contrary to their recorded industrial habits, were so completely abandoned as to become almost entirely forgotten.

England enjoyed an exclusive trade in this metal, until the discovery of tin in Bohemia in the thirteenth century, but from this time the discovery of tin in this and other parts of Germany in sufficient abundance to supply the wants of the surrounding countries made the introduction of British tin unnecessary, and in consequence of the diminished demand it fell considerably in value. English tin is only occasionally referred to afterwards in the commercial records of Germany, although our mines still remain unsurpassed. Those of Banca, however, in the Eastern Archipelago, are perhaps equally rich, both in quality and abundance.

The most ancient records of copper-ore being obtained in this country refer to a grant in the fifteenth year of the reign of Edward III., bestowing, during a term of fifteen years, the right of working the copper-mines of Skeldane in Northumberland, of Alston Moor in Cumberland, and of those near Richmond in Yorkshire. For this privilege the payment of a royalty to the king of one-eighth, and another of one-ninth to the lord of the soil, was considered an equivalent. Subsequently, a rich copper-mine was worked at Keswick.

Some estimate of the extent to which metalliferous mining was carried on during the reign of Edward III. may be formed from the fact that Edward the Black Prince defrayed the whole expenses of his French wars by his successful mining operations for tin and lead in Devonshire.

With regard to the details of mining in Europe as practised in the Middle Ages we know little, but it is certain that the miner selected for his first operations an exposed vein or bed on the slope of a hill; the extraction of the mineral, therefore, was at first simply a quarrying operation. He, moreover, availed himself of the hilly character of the ground to drive an adit down the hill as far as the natural drainage from above extended, and he was thus enabled to sink a shaft without the expense or the inconvenience of machinery

for raising water to the surface. When, however, adits could no longer be driven, the mine was either perforce abandoned, or had to be relieved of its excess of water by mechanical appliances. The necessity for this removal of water was gradually forced upon the miner as the mineral stores near the surface became more and more exhausted; and though there is thus no clear line of demarcation between mining by adits and mining by shafts with the aid of lifting-apparatus, yet the former characterises the mining operations of the Middle Ages, whilst the latter has been chiefly practised during the Modern Period, and has in recent times attained the highest perfection.

Before the use of gunpowder, the work of detaching portions of hard ore was exceedingly laborious. Gunpowder was first employed in the blasting of rocks in the Hartz Mountains in 1120, and we may be sure that an agent so powerful and economical was soon in demand by the miner. Its employment, indeed, may in part account for the increased productiveness of mines towards the close of the Middle Ages and in the sixteenth century. The art of blasting has remained very nearly the same since the first miner "jumped" and "charged" a bore in the stubborn rock which till then had been attacked only with the hammer and wedges.

With the exception of gunpowder and the tools its use called forth, the mechanical appliances of the miner continued to be the same as those employed by the Romans.

SECTION II.—SMELTING.

In mediæval times little advance took place in the smelter's art, and no additions were made to the list of useful metals or their alloys. The smelting of tin appears to have been conducted after the same methods as those practised in the time of the Phœnicians. An order of King John (1201) allowed the miners of Cornwall and Devon to dig

tin and turf, and to melt the metal anywhere on the moors. These and other special privileges extending to the lands on which the Crown claimed rights, go far to justify the supposition that our modern mine-laws are perhaps a relic of the Roman period. As bellows were known at least a thousand years before Pliny, we have here all the materials for a successful tin-smelter's hearth.

During the Middle Ages, silver-ores appear to have been reduced by heat. Munster, Agricola, and Wormius declare that it was found pure in many places in Germany, and that it needed no refining by the fire. The process of desilverising lead appears to have fallen into desuetude in England since the Roman occupation, and we find Bacon deploring "the loss of so many millions of bullion as have from time to time been exported out of England in our native lead, merely for want of skill and stock to carry on so great and noble an undertaking as the extracting of silver out of great quantities of lead."

In the smelting and refining of iron by a continuous operation there are three different stages—the roasting of the ore, the reduction of the metal, and its agglutination and refining. In the Catalan or Corsican forge—a relic of the Middle Ages, which still survives in the Pyrenees and in a few isolated localities in the South of Europe—these processes are practised at a single heating, malleable iron being made directly from the ore. The blast is usually produced either by a water-blowing machine or by a wooden engine with a square piston.

The great improvement during the Middle Ages consisted in the gradually increasing height of the furnace consequent on the use of refractory ores. This necessitated a special means of withdrawing the reduced mass of iron ("lump" or "bloom"), and the operation was effected through a lateral opening in the hearth or lower part of the furnace. With the increased length of the process—the reduced metal being left for a considerable time in contact with the fuel—

facility was given for a greater absorption of carbon, and thus a larger quantity of pig-iron was produced. Karston states that although the knowledge of pig-iron dates from time immemorial, its use and systematic production do not date farther back than the end of the fifteenth century. In England the blast-furnace was probably very early in regular working order, as ornamental castings were made in Sussex in the fourteenth century.

SECTION III.—THE SMITH.

The Middle Ages are emphatically the "age of iron." As soon as settled states evolved themselves out of the chaos of migrations, the abundance of iron in the western and northern parts of Europe began to be turned to good account. The art of forging was practised but imperfectly until the Germans directed their attention to it. Their smiths' work was soon so highly valued that, although labour was deemed servile, an exception was made in favour of the smith. A smith or armourer was an essential functionary in the household of a martial noble, as well as in the royal palaces; and, during the turbulent reigns of the early Norman kings, when the smith's art was called into special requisition, a skilful iron-worker received the highest consideration. The killing of a smith, even though he might be a bondsman, was punishable by the heaviest fine.

The handicraft of the smith is the first in which we light upon the principle of division of labour in the industrial arts. Special reference is made to the shield-makers, who, in the reign of Charlemagne, were a distinct order amongst iron-workers. The making of iron utensils, tools—such as augers, files, hatchets, and saws—cutlery, rings, spurs, iron wire, and spoons, became separate departments of industry. In the second half of the fourteenth century new arts sprang up, and wire-drawing, and needle, thimble, and gun making came into vogue.

The coats of mail in which the knights were clad were

trophies of artistic skill, being often beautifully inlaid with gold and silver. A yet higher range of skill was exhibited both by the compass smiths and by the clock and lock makers, whose masterpieces were as ingenious as they were elaborate.

In the middle of the ninth century there is recorded "the sale of half a smith," that is, of half his time, together with the profit of his labour. Until late in the tenth century, the bishops of Strasburg claimed unpaid service from the smiths of the State. They were compelled to furnish and keep bright all the equipments requisite for the Court, whether for war or for purposes of hunting. But we are not surprised to find that a craft to which the warlike spirit of the age gave the utmost importance was very early emancipated from the fetters of feudal servitude.

SECTION IV.—THE COACHSMITH AND THE FARRIER.

Though agriculture was pursued with great zeal by the rising nations of the Middle Ages, we find in the inventory of the tools on one of the farms of Charlemagne only two spades and two shovels, together with two large and two small sickles. No mention is made of wagons, carts, or ploughs. Vehicles for carrying off the crops from the fields could only be of service where roads existed, and these, as is well known, were few and ill-kept. Until the end of this period the common mode of travelling was upon horseback, and merchandise was conveyed by means of pack-horses. Highways had been so long neglected that their reconstruction was necessary before draw-carts could come into general use. The gates of cities also were made purposely narrow, for defence, so that wheeled conveyances, in order to pass in or out, were

obliged to be inconveniently small. The queen of Charles of Anjou, about the year 1282, entered Naples in a kind of coach. Philip the Fair, of France, interdicted the wives of citizens of Paris from riding in wagons or carriages, in emulation of the ladies of the Court. Although this edict indicates that the fashion was spreading, yet there were but two carriages in the French capital in the reign of the magnificent Francis I., and the coach of Henry IV. was a rude structure, with neither springs nor straps. Coaches were a Hungarian invention. The name, which belongs to the language of the country, refers properly to a covered carriage suspended on straps. The pleasant oscillations of such a structure formed a vast improvement upon the joltings of cumbrous vehicles; but, nevertheless, for a century after their introduction into France, they were merely re-regarded with curiosity as a speciality belonging to royalty. Coaches, under the designation "whirlicotes," were not made in England until Elizabeth's reign, and we find that it was one of the ways by which Lord Bacon plunged himself into debt, that, in conjunction with his brother, he "set up a coach."

Farriers or shoeing smiths appeared first in Germany. The shoes referred to by ancient writers as being worn by camels and horses were rather socks of ox-leather, or of some other durable substance, which served as a protection during inclement weather. The roughness of German travelling, and the fact that the normal state of the people was that of war, made such clumsy protective coverings insufficient. Horseshoes were, therefore, wrought in iron, in the working of which the Germans were becoming expert. This practice was introduced into England at the Norman Conquest. The chief inspector of the farriers, Henry de Ferrers, owed his name to his office, and his descendants still exhibit a coat of arms bearing six horseshoes. The advantage of shoeing in iron was quickly recognised, and before the Middle Ages terminated there was

not a country village without its smithy. In towns the farrier's art is now a distinct one; but in country places the farrier and blacksmith are still often united in the same man.

SECTION V.—THE LOCKSMITH.

The locksmith's art during the dark ages was only partially called into requisition. Under feudal tenure there was but little movable property. Fixed property was in the hands of but few, upon whose estates the bulk of the people were born, and lived, and died as serfs. The rude habitations of the people were defended by cross-bars of timber, while strong beams barred the entrance to baronial castles. There was thus little to put under lock and key, except in the case of the Church communities, to which we mainly owe the preservation of the locksmith's craft. In the cathedrals of the period the locksmith's work was especially elaborate and ingenious. The carved shrines and cabinets of the altar were decorated with metal-work, and their doors furnished with locks. The reliquaries and the chests for ecclesiastical ornaments were bound and secured. Locksmiths, however, were not separate from smiths generally, as it was upon these last that the bishops of Strasburg made claim for all that appertained to the chains, bolts, bars, locks, and other fastenings throughout their palaces.

The first reference made to locksmiths as an independent trade is at Nürnberg, in 1330; and allusions to the most noted craftsmen are afterwards not unfrequent.

Du Cange mentions both locks and padlocks in 1381, and before the mediæval period had lapsed the locksmith's art had arrived at great perfection. Pursued more than other handicrafts by isolated workers, there was not sufficient *esprit de corps* to form a gild; this, however, was compensated for by the ardour of the artist, whose devotion and genius

produced trophies of skill which raised him above the rank of a mere operative. Some of the ironwork still remaining, such as gratings, knockers, locks, bindings, hinges, and bolts, are examples both of good taste and minute decoration. Tubular or barrel keys—the shafts being cylindrical, triangular, or square—were fitted upon a corresponding shaft or axis in the lock, as a centre of leverage. Smaller keys of similar pattern were slung at ladies' girdles, as a symbol of their office in the household, a fashion imitated in the present day in gentlewomen's decorated *chatelaines*.

Lock-making was undoubtedly the parent of much of our machinery. Its complex and ingenious arrangements afforded practical insight into the principles of mechanics. Clock-making undoubtedly arose out of this art, and was at the first also consecrated to the use of the Church. The same artificers made the machinery both for clocks and locks.

The city of Nürnberg was the most renowned for its mechanical skill. Here it was that, in 1517, the match-lock was invented, and subsequently the firelock was so much improved as to bring about a complete revolution in the modern mode of warfare. One of its citizens made the first secret or puzzle-lock, which, by a series of permutations and combinations of a few movable rings, varied the fastening and opening of the lock in nearly 50,000 ways. Such locks afterwards occupied much of the time and talent of the ingenious mechanicians of France, who produced, amongst other curiosities, a lock-bolt that fired off an alarm shot. The trunks of Nürnberg still remain masterpieces of strength, being composed wholly of iron, bound together with brass, and secured with skilfully-devised locks. Safety was still further obtained by the invention of fastenings that required several keys to open them. Mechanical ingenuity was equally exhibited in the invention of the breaking-screw, for the purpose of forcing open the strongest doors, and for breaking down the firmest walls.

SECTION VI.—THE SWORDSMITH AND CUTLER.

It was amongst the Germans that the manufacture of steel first assumed importance. The sword was the mark of a free man, no serf being allowed to carry one. Their fabrication drew forth the genius of the most skilful artificers, and special histories attached themselves to many of the weapons. Such a sword was that of Conrad, governor of Suabia, which was six and a half inches at the handle, and twenty-two and a half inches in length. The great hero of early days was Wieland, who for a wager produced a sword that severed a piece of fleecy wool as it floated lightly in the air, and who afterwards, in a passage of arms, tested a second by cleaving through, at a single blow, the skull and helmet of his opponent. The Saxons are said to have derived their name from their swords—*seaxas*.

For several centuries swords were called knives, and swordsmiths knife-makers. Thus Charlemagne is described as having his "knife" always at his side, and invariably employing it as a standard of measurement. The swords used in these times differed from the ancient weapons, in being pointed, long, and narrow. Two-handed swords came into vogue in the fifteenth century. They stood as high as the men who wielded them, and were much used by the citizens in their contests with the barons. Damascus and Toledo blades have always been prized. Daggers also grew in favour, and the custom became common of decorating them, as well as swords, with highly-wrought artistic handles. Knives and forks are now viewed as such essential parts of the dinner-service that we can scarcely realise the fact that our ancestors managed without them; yet for many centuries only one knife was put upon the table. Knives were too valuable to be provided by the host, and every guest brought his own, suspended at his girdle. It is now regarded as impolite to eat with the knife; then, how-

ever, it was employed to take the meat directly from the dish. England was early famous for its knives, which were thought worthy of being presented to the Pope. Sheffield and Hallamshire have always been the chief seats of this and of the other branches of cutlery. Forks appeared first in Italy, and were thought to be effeminate articles of luxury, designed to save the bread or the table-napkins.

Associations of cutlers and swordsmiths originated in Germany. Their earliest corporate appearance is in Augsburg, in 1301; long before this date, however, their division of labour was distinctly recognised, for their services were claimed at Strasburg in 982, apart from those of smiths in general. German cutlers and swordsmiths stamped their names and trade-marks upon their goods. Their coat-of-arms consisted of three daggers in a field of azure. A festive anniversary was observed by them for several hundred years, under a privilege granted by the Emperor Charles IV. This privilege, it appears, was accorded in acknowledgment of assistance rendered to the ruling authorities in an insurrection of the burghers. They were able to furnish invaluable help, not merely from their courage and skill in wielding the weapons they fabricated, but from their power of acting in concert through the medium of their trade-unions, four of which were then in communication in the important towns of Augsburg, Basle, Munich, and Heidelberg.

SECTION VII.—THE ARMOURER.

Armoury does not appear to have made very rapid way at first, for although Charlemagne demanded from his militia, helmets, greaves, and harness—which last comprised armour in general—yet it is only from the tenth to the thirteenth century that the knightly suits of mail form the theme of the poets. From the period of the Norman Con-

quest the varying fashions can be traced in the effigies of the monarchs upon the great seals of state, and in the monuments of the barons. The chief part of the armour was the chain or ringed hauberk which covered the body and legs, and continued in use, subject to minor changes, to the year 1400. During the twelfth and thirteenth centuries this kind of armour was made so flexible that it fitted close to the body. The fabrication of a suit required the highest skill, every link having to be made and fastened separately. Imbricated plates of bright steel, and of a heavy, massive character, opening both in front and behind, began to be worn over a sleeveless tabard or shirt. This was the fashion among the warriors who sought to rescue the Holy Land from the Saracens. The splendour of the Orientals, however, astonished their invaders, and created in them a taste for similar magnificence. Princes wore plated coats of costly silver, and the usual panoply of knights consisted of suits of mail made of burnished or blue steel, often inwrought either with gold or with gilded copper. Steel gauntlets covered the hands, the plates being jointed so as to allow of their being adapted to every movement of the fingers. Scale armour was eventually extended to the horse, and both the knight and the animal he bestrode often presented to the lance one complete surface of steel. The battles of Morgarten, however, in 1315, and of Nancy in 1477, proved that burghers, with their great cause at stake, were more than a match for mail-clad knights.

From the year 1100 references are often made to the subdivisions of armourers, such, for example, as platers and makers of coats-of-mail, "harness"-makers, helmet and skull-cap manufacturers, bow-makers, weavers of chain-armour, and armour-burnishers. The armourers of Nürnberg and Augsburg were the most famous in Germany, and were generally employed by the emperors and princes for the rich suits it was their custom to wear.

SECTION VIII.—THE PEWTERER.

Tin-founding assumed much importance in the fourteenth and fifteenth centuries, particularly in the cities of Prague and Nürnberg. The silvery lustre of the metal, its slight liability to tarnish, its cleanness and convenience, gained it favour for many purposes for which the potter's art had previously been used. Tin possesses the remarkable property of forming alloys, which are soft, hard, or brittle, according to the proportions of the blended metals.

Lead, which when used alone is noxious, becomes perfectly harmless in the condition of pewter. The rows of bright plates and dishes arranged on the shelves of the kitchens were the pride of the industrious housewife of the Middle Ages. Every inn was well equipped with bright tin tankards and cans; and this branch of handicraft was so extensive as to require in Nürnberg a distinct department of industry: it increased so much, that the "shambles" first allocated to the craft had to be enlarged to accommodate the operatives.

SECTION IX.—THE COPPERSMITH.

As the art of working iron extended in Europe, copper grew into comparative disuse. It, nevertheless, continued in request for artistic objects, such as candelabra, fonts, and monumental brasses, both chased and engraved. These works improved in design and execution throughout the Middle Ages, attaining ultimately a high degree of excellence. Scarcely a reference, however, is met with to the productions of the coppersmith, as distinguished from those of other workers in metal. As the Modern Period dawned the value of copper in the industrial arts began to be more recognised. Pan-smiths, kettle-smiths, and coppersmiths were to be found in Augsburg, and especially in that

centre of German handicrafts, Nürnberg, where there was a "Pan-smiths' Row," and where vessels of every size were made, from the vast boilers used in brewing to the smallest stewpan. All these workers, however, were comprised in the general gild of smiths and forgers, a fact which in itself proves the still inconsiderable character of the copper-worker's art. Nevertheless, on the whole it must have been of value, for Nürnberg merchants bought copper in the markets of Flanders, and distributed the products of their skill to all parts of the commercial world. Merchants and masters grew rich—so much so that one of them was charged with transmuting copper into gold and silver, which in one sense he did, but only through the agency of "hand and hammer." So greatly prized, indeed, were the copper manufactures that the free-booter knights thought it especial good fortune if they chanced to capture articles made of that metal. German kitchens to this day reflect, in many burnished copper equipments, the extent and perfection of this antique art.

Copper-work received a great impetus in the thirteenth century from the discovery or development of new mines. Those of Fahlun, in Dalecarlia, are amongst the oldest and most celebrated in Europe, and, as artificial excavations, are very remarkable. Mines, too, were opened in Hungary; and copper began also to be abundantly obtained from Bohemia. Copper-mining was pursued in Meissen with the extended means of an associated company, and works were erected in various places.

SECTION X.—THE BRAZIER AND BELL-FOUNDER.

Brass-work, often confounded in history with that of bronze, was an important employment in early times, as is shown both by the relics of the manufacture and by the crucibles still existing in which the metal was melted.

The folding-doors and pillars of the cathedrals, chris-

tening fonts, bells, candlesticks, and memorial tablets were of this metal, and examples are extant in Hildesheim, Augsburg, and Mentz. During the Renaissance Period artistic designs and skilful workmanship reached their highest point, and many designs were of the most beautiful and massive character.

With the introduction of gunpowder new demands were made. Cannon and bell-founding were both recognised departments of industry before the close of the fourteenth century, and in the century following were, with every allied art in brass-work, energetically pursued. The alarm-bell of Nürnberg, cast in 1339, weighed two tons; and the tomb of Sibaldus, with its figures in relief, remains as a masterpiece of early art.

The braziers, towards the approach of modern times, were numerous enough to form successively, at short intervals, many affiliated gilds. Wire-drawers and brass-beaters, thimble and basin makers, button-makers, weight-makers, handbell and lute makers, compass-makers, and, finally, modellers, who prepared the patterns for founding, are all registered between 1360 and 1470; and in the same period there originated in Nürnberg the Brassfounders' Row and two Braziers' Streets.

Turning-lathes, ingeniously constructed for shaping and polishing objects, whether large or small, and wheels for grinding—water being the motive force—were introduced at about this period.

SECTION XI.—THE GOLD AND SILVERSMITH.

Between the luxurious profusion of the Roman Empire and the simplicity of Gothic times the contrast was extremely great. A strong love of ornament, however, prevailed among the German tribes, and descriptions have been handed down of dresses of gold and jewels, with hair pins which resembled birds and serpents. Numerous works of the Merovingian

age illustrate the condition of the goldsmith's art. There is preserved, for example, the golden armour of Chilperic, the Frankish king, who died A.D. 584, and the regalia used at the coronation of Charlemagne are still in the Imperial treasury at Vienna. In the injunctions issued by the latter monarch relative to the furtherance of industry in his dominions, artificers in gold and silver are repeatedly mentioned. Above all, the religious devotion of the age, perverted though it was to a great extent, gave abundant encouragement to the art of the workers in the precious metals. No gifts to the Church seemed to be regarded as too costly. Thus it was that a vast accumulation of gold, silver, and jewels was gradually made. Although mining was for some time neglected, enough remained from the Roman spoils to enrich and beautify the shrines and churches. Not merely were the sacred vessels and the requisites of the altar—as the chalices, censers, candelabra, and crucifixes—made of gold and silver, and enriched with priceless gems, but the very altars themselves and their approaches, and even the screens, pillars, and folding-doors, were covered with the same precious metals. St. Peter's, at Rome, was especially magnificent in this respect, the weight of its altar appointments exceeding 6 cwt. The massive rafters, together with much of the flooring and of the principal entrance-doors, were inlaid with gold and silver. Charlemagne presented to this cathedral a golden table furnished with an invaluable set of sacred vessels. The same monarch placed in the cathedral at Strasburg a golden crucifix four yards high, weighing $2\frac{1}{2}$ cwt., and King Dagobert had previously given to it a copy of the Evangelists studded with jewellery, together with a golden cup and basket, similarly adorned. The passion for giving to the Church, more especially in the form of death-bed presentations, continued throughout the Middle Ages. We have an illustration in the gifts of land which, in England, in the reign of Henry III., led to the Statute of Mortmain.

Attached to the various monasteries were treasuries for the safe keeping of the gold and silver service of the altar. Laboratories and studios, too, were set apart for the fabrication by the monks of manifold sacred requisites. Golden rings, chains, bracelets, buckles, and spiral circlets were the chief productions in articles of personal adornment. They are the constant theme of the songs of the minstrels of chivalry, and were the usual tokens of love, friendship, and courtly honour. Betrothal rings, set with pearls and gems, were worn by maidens who had plighted their troth, and all ladies took delight in heightening their comeliness with jewellery. Jewelled diadems were worn, while garlands or chaplets of precious stones and pearls were intertwined with their tresses, as we have already related in Chapter III.

Between the time of Charlemagne and the end of the twelfth century, the mines of Bohemia, the Hartz, and other parts of Germany were discovered, and added much to the rich stores then in existence. Other German mines were found before the discovery of America, and their gross annual yield was far beyond what Germany now affords. Silver was the first precious metal to be worked, masses of ore being often met with just beneath the surface of the soil. One such, long used by the Margrave Albrecht, of Meissen, as a table, yielded, on being smelted, 450 lbs. of pure silver. Bohemia was described by the king of the country, in 1295, as sufficiently productive of the precious metals to supply the wants of the world. The Saxon mines yielded an annual land-tax of 100,000 Bohemian groschen; while those of Schneeberg, in the Erzgebirge, produced, during the first thirty years of their working, an annual average of 10,000 cwt. of silver. Other mines as rich were afterwards opened in the Tyrol and at Salzburg. From these causes, combined with the spread of freedom and of commerce, the wealth of Germany grew very rapidly, and became generally diffused. It was no rare thing for a merchant to

use in his household solid gold and silver for purposes for which in other states pewter was provided. Pope Pius II. (1458), the learned Æneas Sylvius Piccolomini, apostrophised the Germans on their riches and magnificence in the following terms :—"Where is there even an inn in which you do not drink out of silver? What—I will not say noble lady—but what citizen's wife is not brilliant with jewellery? What shall I say of the collars and other horse accoutrements made of the finest gold, of the spurs and dagger-sheaths set with jewels, of the earrings, shoulder-belts, coats of mail, and helmets, all of glittering gold? What costly ecclesiastical treasures! How many reliquaries set in gold and silver! How great is the decoration of the churches, on the altars, and in the garments of the priests! Can there be met with anywhere more wealth than in your sacristies?"

Enough has been advanced to indicate the importance at an early date of the goldsmith's art. Like other artificers, the goldsmiths were serfs until the tenth century, but even when in bondage they possessed the privileges of holding property and of inheritance. They were amongst the earliest to establish free gilds, and are mentioned in increasing numbers in the most flourishing towns of Germany during the rest of the Middle Ages. They were also the coiners of gold. Many celebrated goldsmiths have handed down their names from these times to our own. The art assumed such dimensions that proper officials were appointed for stamping and weighing the precious metals, as a guarantee of their purity and value. This custom began at Nürnberg, and was soon copied at Ulm and other places, nor was it lawful to sell the metal before it had the authorised *imprimatur.*

CHAPTER V.

Arts relating to Man's Intellectual Nature.

SECTION I.—TIMEKEEPERS.

The Clock and Watch Maker.

The first time-measurer was undoubtedly the arch of the heavens, with its sun and stars, whose rising and setting formed the grand chronometer of Nature. This, nevertheless, was for several reasons unsuitable and insufficient for human transactions.

The devising of schemes for registering the progress of time, and ascertaining it at any hour by day or night, has been by no means easy; it was a difficulty which required centuries of careful study and observation to surmount. We have seen that the first attempts made by the ancients were rude and imperfect, and that the instruments they used were the sun-dial, the clepsydra, and the sand-clock. Up to the eighteenth century the sun-dial was still in actual service as a recorder of time, but it is of course useless at night or during cloudy weather.*

All the clepsydras of the ancients appear to have had one common failing. There was a general inequality in the flow of the water from the orifice, resulting from the variability in depth, which caused a diminution of pressure as the water sank in the vessel. At first, the liquid would escape rapidly, then more slowly, its flow varying with the height of

* "Horas non numero nisi serenas" (I number none but sunny hours).—*Old Device.*

its surface above the hole. These water-clocks, therefore, required much careful regulation, but they continued in use throughout a considerable part of the Middle Ages. The first water-clock known in England was brought over from France by Richard Cœur de Lion, a few years before he ascended the throne.

The modern sand-glass was invented in France, shortly before the accession of Charlemagne, by a monk of Chartres, named Luitprand, who also re-invented the blowing of glass, after the secret had been lost for centuries. His sand-glass was the exact prototype of all those which have since been manufactured. It consisted of two pear-shaped bulbs of glass, connected with each other by means of a short tubular stem, through which the sand flowed. At the end of a certain time, when the upper glass was empty, another similar period of time could be marked by simply inverting the instrument. Sand-clocks afterwards became common throughout Germany, and subsequently were sent from Nürnberg to all parts of the world. It was not until the reign of Edward the Confessor (1041—1066) that the use of hour-glasses became common in England. The famous astronomers, Rivalters and Tycho Brahé, made use of them in their observatories. Besides being applied for domestic purposes, they were regularly employed in the Scotch churches, and provided also in many English ones, to determine the divisions and duration of Divine service.

There were, besides these, other modes of computing time, some of which were adopted by our own forefathers. King Alfred, for example, who reigned A.D. 872—900, devised a method by means of a candle set in a lantern, which marked the time by its rate of burning.

The history of the invention of clocks and watches is very imperfectly known. The first clocks were, no doubt, very rudely constructed, their present state of excellence having only been attained by slow and successive improvements. It is impossible to point out any individual who

could, with propriety, be called the inventor. By some, the first idea has been ascribed to Pacificus, Archdeacon of Verona, in the ninth century.

As early as the eleventh century, the Saracens are supposed to have had timekeepers which were moved by weights; and as the term clock is applied by Dante to a machine which struck the hours, clocks may have been known in Italy about the end of the thirteenth or the beginning of the fourteenth century. It is said that the first made in England was furnished for the famous clock-house near Westminster Hall, out of the proceeds of a fine imposed upon the Chief Justice of the King's Bench, in 1288, and that it remained in its original situation in the Old Palace Yard as late as the reign of Queen Elizabeth. The first at Bologna was put up in 1356. The most ancient of which we have any reliable record is that erected in the round tower of the palace of Charles V., King of France (now the Palais de Justice), in 1370, by Henri de Vic, an Arab who had been converted to Christianity. This clock was a monster machine, weighing 5 cwt., and attracted crowds every day for several months after it had been erected. Henri de Vic, the maker, was ennobled, and received a life-pension of one hundred crowns of gold; he is the first artificer upon whom this distinction was ever conferred in France. From this time the making of large clocks for public buildings was extensively carried on all over Europe. One was erected at Spires in 1395, one at Nürnberg in 1462, one at Auxerre in 1483, and one at Venice in 1497; and in the sixteenth century public clocks were possessed by all the principal towns and cities of Europe. Watches begin to be mentioned towards the end of the fourteenth century. The invention, a natural outgrowth of the art of clockmaking, is ascribed to Peter Hemlein. Dopplemeyer relates how they were first put together in the sixteenth century, and went under the name of "Nürnberg eggs." This reference is probably to an

improved kind, for numerous stages of invention had to be passed before a watch could be made with springs and fitted for the pocket.

SECTION II.—MUSIC.

Elementary Principles of Sound.

The sensation of sound is produced by vibrations communicated to the air from a vibrating body, and conveyed in aërial waves to the *concha*, or external ear, which collects and transmits them to the *tympanum*, or drum. Corresponding vibrations are thus produced on the tympanum, and these are transmitted along the winding passages, called the labyrinth, to the auditory nerve, or organ of hearing. When the aërial vibrations are repeated irregularly, or in regular succession at distinct intervals, a noise is the result; as for instance, the sound produced by a hail-storm, or the rumble of a heavily-loaded wagon. If, however, the aërial vibrations are regularly repeated, and follow each other in such rapid succession as to render the interval between each vibration imperceptible, then the sounds become continuous, and a musical note is produced, which excites in all who possess a moderate share of nervous sensibility in the hearing organs a sensation of pleasure. A fixed number of vibrations per second produce a given note. Low notes are the product of slow vibrations, which increase in frequency as the note becomes more acute. Extremely low or high notes are inaudible. The point at which a series of vibrations ceases to give an appreciable sound, either from their slowness or their rapidity, is different to different ears. Dr. Wollaston found, by experiment on the sense of hearing, that an appreciable difference existed. Some by no means deaf he described as being unable to hear the cry of a bat or the chirp of a cricket; whilst to others the same sounds were painfully shrill. He also discovered that very low notes, which to some were inaudible, could be heard with distinctness by

others. These observations led to the opinion that the average extent of the scale of musical sounds appreciable by the human ear is limited to about nine octaves, extending from the lowest note of the organ to the highest known cry produced by insects. These few remarks on the principles at the basis of music as a science are simply offered to the reader as introductory to our remarks on the practice of music.

Ancient Bards and Minstrels.—As the Greek and Roman music passed away, the sombre groves of ancient Germany became resonant with sound. The people rejoiced in the voice of melody and in the clang of instruments, which made a music that, according to Roman historians, was indeed terrible. The love of music, a national feature of ancient Germany, as it is now of modern *Deutschland*, was conspicuous everywhere, and under all circumstances. The soldiers sang as they marched to battle; and on every joyful occasion, at the banquet especially, the harp was passed round. So Caedmon essayed his song of triumph, or chanted his sacred hymn.

But there were also in Germany wandering minstrels, who made it their especial business to sing to their harps old and cherished songs. Like the ancient bards of Ireland and of Wales, they formed a peculiar class, travelling from people to people, and from one royal court to another. Our information about these, derived as it is mostly from classical sources, is very scanty. Tacitus says: "The Germans used martial songs, by the recital of which they sought to increase the fury of their warriors, whilst from the effect of their strains they drew omens as to the issue of the coming battle." Strabo says "that the bards among the Gauls (βάρδοι) were not only singers of hymns, but also original poets." There is no doubt that at a very early period they were spread over the greater part of Western Europe, ultimately disappearing before the advance of a higher civilisation.

Musical Instruments.

Besides the harp, flutes, lutes, and kettle-drums were in use from a very early period; barrel-organs, the rote (an instrument resembling the hurdy-gurdy), horns, trumpets, and drums were also gradually introduced.

This love of music showed itself throughout the Middle Ages in the encouragement everywhere given to minstrelsy. From every part of Germany musicians streamed forth; German fiddlers and Bohemian flute-players travelled into neighbouring countries, and German instruments were highly valued both in Provence and in Italy. Even men holding the highest rank practised the art of singing and playing. The Hohenstaufen emperor, Frederick II., and his son Manfred, were themselves both writers of verse and patrons of poets; and we are told how, on still nights, Manfred would repair to the sea-shore with his retinue of singers, to amuse himself with minstrelsy. We have, too, in English history a well-known traditional illustration, in the case of Cœur de Lion and Blondel.

At the tournament and in the hour of battle, trumpets and flutes were generally heard; with these the signal for attack was given, and every military movement regulated. The other martial instruments which enlivened the heart of the soldier were pipes, tambourines, trumpets, and kettle-drums. The trumpet appears to have first come into common use towards the close of the Middle Ages.

The Pianoforte.—About this time the instruments made their appearance which preceded and ultimately produced the pianoforte. Guido, of Arezzo, perfected the monochord, used for ascertaining the relative proportions of musical sounds, an invention which has been attributed to the genius of Pythagoras. The monochord consisted of a single string, stretched over two bridges at the extremities of a graduated rule. Guido, in his "Micrologus," a work of the eleventh century, recommends this instrument, giving direc-

tions for its division according to his system. From the monochord subsequently arose the clavichord and the harpsichord, and then the spinette and the virginal. These instruments were of a louder tone, and were sounded by what were called jacks. These were pieces of box-wood fitted with a quill, which, by the pressure of the keys on the keyboard, were made to strike against the strings of the instrument, and thus to cause their vibration. Successive improvements at length produced the pianoforte. In this instrument sound is produced by the vibration of wires, which are struck by hammers with surfaces of leather or of felt. The lever which impels the hammer against the string raises at the same time a damper from the upper surface of the wire, so as to allow a free vibration. On the removal of the finger from the key, the damper falls upon the string, and checks all further sound. The first idea of this instrument originated with Viator, a German mechanic; through want of friends and funds, however, he never became a manufacturer. German musicians and makers henceforth ceased to make clavichords and harpsichords, and turned their attention to the new instrument. The idea suggested by the clavichord originated the square piano, which still retains the shape of the former, with the same disposition of strings and keys. The grand pianoforte was the invention, some say, of Schröder, a German musician, whilst others declare it to be the conception of Christofali, a harpsichord dealer, of Padua. Its form originated from that of the harpsichord. The upright pianoforte, which is taken from the upright harpsichord, is the invention of Hancock, an English musical instrument-maker.

No instrument is so deservedly popular as the pianoforte. Its compass is sufficient for every kind of composition, and it may, in fact, be regarded as a sort of miniature orchestra.

The Organ.—Another still more important musical discovery arose in very early times. The organ, in its present perfected condition, is undoubtedly the noblest, the most

majestic, and the most comprehensive of all instruments, whether considered in regard to the variety of its powers, the grandeur and beauty of its sounds, or the sacred purposes to which it is usually devoted.

> "—— Through the long-drawn aisle and fretted vault
> The pealing anthem swells the notes of praise."

It has lost none of its ancient prestige, and still maintains its pre-eminence over every other instrument which man has invented; and such will probably be its position for coming generations.

The organ is a wind instrument, consisting of a number of metallic and wooden pipes. These are divided into different stops of the same quality of tone, the wind is admitted by means of bellows, and the whole is played upon through the medium of a keyboard. A piece of ordinary music may be played upon one stop, but to produce a combination of sounds differing in quality, several are drawn out simultaneously. The number of stops may, of course, be increased or diminished at the pleasure of the performer. When all the stops are "out," the effect of the organ is similar to that of a full band. It is supposed to have been an improvement on the hydraulicon, or water-organ, of the Greeks, invented by Ctesibius, of Alexandria, B.C. 150, who employed water for the purpose of supplying air to the pipes. It is uncertain when the organ was first introduced into the services of the Christian Church. The most reliable account of its appearance in Europe is that the Greek Emperor Copronymus, A.D. 755, sent one as a present to Pepin, King of France. Charlemagne received organs from Greece, and had one constructed from a Greek model, A.D. 812. This is considered by the learned Benedictine, Bedes de Celles, to have been the first that was furnished with air by means of bellows, without the use of water as a motive power. In the tenth century they were common both in England and on the Continent.

At first they were but rude in construction and extremely limited in compass. In the twelfth century the pipes were of brass, and the music somewhat harsh. The compass did not exceed twelve or fifteen notes, since this was all that was needed for the simple plain-chant then sung. The keys were six inches broad, and so wide apart that they could only be played on with the fists and elbows. It was not until the fifteenth century that organs received any very considerable improvement in structure.

Progress of Musical Science.

Musical science advanced slowly, but its foundation was good and its improvement sure. To point out all the obstacles which were overcome in ascertaining its laws or in bringing out the secrets of rhythm, time, melody, and harmony would be difficult. We are told, in the histories of Flanders, that in the tenth century Hibaldus, a monk, made the first attempts at harmony, by the blending together of several notes sounded simultaneously, so as to form a chord. He also added two lines to the staff already employed, and made use of the spaces. A century later, Guido, of Arezzo, already referred to, added a fifth line to the staff, and substituted notes for the letters which had hitherto been used as signs for musical sounds. He increased the fifteen notes already known to twenty-two. In the twelfth century, Franko, of Cologne, taught the measuring of time, and improved the theory of chords and discords. With the use of artificial notation, melody and harmony were free to develop themselves, although centuries were still needed to complete the rules of the art. The cultivation of musical science now became general, but it was chiefly fostered in Italy and in the Netherlands. In the latter country the art of counterpoint, or the arrangement of music in parts, first attained great perfection about the year 1380, through the efforts of Wilhelm Dufay. In Italy, in the fifteenth century, music was brought into the Courts, chapels, and schools of

Milan and Naples; and in the sixteenth century Ottavio Petrucci, an Italian, invented at Fossombrone, in the States of the Church, the printing of musical notes with special types.

At the close of the Middle Ages, notwithstanding all these advances so favourable to its better cultivation, music remained for the most part in an imperfect and depressed state. Instruments were still few in number and rude in manufacture. There were no fixed rules to guide the student, who was left to display whatever devices he could on the fiddle or the lyre whilst playing in the dance or at the feast. In the Church, brass instruments of different kinds were sounded in unison with the voice, and were used to strengthen the choir. Church music itself consisted only of one part, and, even in Rome, was so destitute of artistic grace that it is said Pope Martin, in despair, thought of giving it up altogether.

SECTION III.—LITERATURE. WRITING. BOOKS.

When the Western Roman Empire fell before its barbarian invaders, literature found an asylum in the monasteries, which were respected even by the rude warriors who had overthrown the Pantheon. Despite her hostility to heathen literature and sculpture, the Church appears to have kept both from utter annihilation. Hence, throughout the dark ages of the Mediæval Period, some of the inestimable remains of Greek and Roman literature were preserved and handed down to us. To the Arabs, also, Europe owed the renewed knowledge of many of the writings of antiquity.

On the introduction of Christianity, the ancient Runic writing of the Germans was superseded by the Roman characters, the former being condemned as magical and heathenish. The Runic alphabet has been thought by some to be derived from the same source as the Latin, and there

is little doubt about its having been affected by contact with those characters. There are three varieties of Runic letters —the Norse, Anglo-Saxon, and German. The letter "T" or "t" in the Norse-Runic has the horizontal line of "T," only depressed; and its "I" or "i" corresponds to the Latin "I." Other letters, also, are as easily shown to be cognate with the Latin forms, as "ꓘ," which is only the form of "B" with its curves changed into angles; and, in like manner, "d" is connected with "D." The German Runic alphabet was modified by Bishop Ulphilas, who formed for his countrymen, the Mœso-Goths, an alphabet derived from the Greek, with certain elements taken from the native Runes, and wrote in these letters his celebrated translation of the Bible.

There is a legend which attributes the invention of Runes to the god Odin or Wodin, who is said to have settled in Scandinavia, to have built temples, and to have established a priesthood, to whom he communicated the Runic letters, together with the mythology of the Edda. This myth would seem to point obscurely to the fact that the pure Runes were introduced into the North from the East, and that they had at the outset an Oriental origin; that they are, in all probability, like the ancient Greek, the Etruscan, Oscan, Umbrian, Latin, and Celtiberian modifications of that primitive Phœnician alphabet which has given birth to all the modern alphabets of the known world.

Runic inscriptions are found on rings, medals, coins, monumental stones and crosses, and on the sides of rocks. In the department of antiquities in the British Museum, one may be seen on the side of a sword-blade. They have been discovered in Denmark, Sweden and Norway, the British Isles, Germany, France, and Spain; wherever, in fact, the Teutonic race settled during the period of its migrations in the fourth and fifth centuries of the Christian era.

The art of writing in mediæval times was almost wholly limited to the clergy, who taught it only to those intended

for the Church, or to persons of acknowledged wealth and distinction. The books of the period were also written by them, some of which are still extant, and are so beautifully executed as to excite our surprise and admiration. The manuscript of a single work must have been the labour of almost a lifetime. The ecclesiastical scribes were particularly expert in adorning and colouring initial letters. This art was called illumination, and affords definite data by which the age of the manuscripts can be determined. In all the principal monasteries there was a *scriptorium*, or writing-room, in which the writer could quietly pursue his task, assisted generally by a dictator, who read aloud the text to be copied. The transcript, after careful examination, was finally handed over to the *miniator*, who added to it the ornamental capitals and artistic designs. No trace of the ignorance which at this time darkened Europe is visible in the manual skill of these exquisitely-finished manuscripts.

Learning.

In the earliest and rudest centuries of the Middle Ages there was little or no scope for the philosopher. Science was confounded with magic and scorcery; and questions in physics, geography, chronology, and astronomy were all attempted to be settled by an appeal to the Sacred Scriptures. Nevertheless, most important services were rendered to civilisation; and the preaching of the clergy was not without most beneficial social results. Everywhere they proclaimed the Christian doctrine of the fraternity and equality of men, and thus struck at the very root of slavery. It has been truly said that the letter of St. Paul to Philemon was "the first written charter of the emancipation of slaves." Without openly attacking this ancient institution, Christianity shook it to its foundation by the removal of its chief corner-stone—inequality. Emancipation on a large scale was a necessary consequence, and

the first men freed became, many of them, bishops and heads of the growing Church. Nevertheless, ages had yet to pass away before artisans and the lowest strata of society obtained their full liberty.

A knowledge of reading spread very gradually among the laity, and appears to have been more common amongst women than men, especially among such as were rich and distinguished by birth. Matilda, wife of Henry I., after the death of her husband, procured instruction for herself and her courtiers; and Friar Berthold speaks particularly in his sermons of women who were able to read in the Psalter. The first schools for reading and writing were the cloisters at Fulda, St. Gall, and Weissenburg, and the first traces of public schools occur in a few towns in the fourteenth century. Universities sprang up in Italy in the twelfth, and in Germany in the fourteenth century. According to Hallam, the University of Paris dates probably from the early years of the tenth century. Oxford was a flourishing university in 1200, and Cambridge is first mentioned by Matthew Paris in 1209. Of the foundation of the former, the same writer thinks that it might possibly be ascribed to the time of Alfred. The oldest in Germany is that of Heidelberg (1386); that of Erfurt followed, in 1392, and in the fifteenth century those of Leipsic and Rostock. The instruction was, for centuries, principally oral, owing to the value and scarcity of writing materials. Papyrus was used even up to the eleventh or twelfth century, the latest known document written on this material being the bull of Paschal II. in favour of the See of Ravenna.

PAPER.

After the sixth century cotton paper began to come into use. It was prepared by the Arabs, who are said to have learnt the art from the Chinese. The Arabs seem to have carried the art to Spain, and to have there made paper from linen and hemp, as well as from cotton. The oldest docu-

ment on linen paper belongs to the year 1308. The first paper-mills appeared in 1340, in the castle of Fabriano, near Ancona, and in 1390, in Augsburg and Nürnberg.

Influence of Moorish Civilisation.

Just in the darkest period of the Middle Ages the Saracens arrived as conquerors in Spain (713). They were at this time astronomers and mathematicians, and had made invaluable contributions to human knowledge. Very little is known about the appliances used in scientific investigations during the long interval from the Greeks and Romans to the Saracens. The nature, however, of the ordinary mathematical instruments, such as circles, levels, and surveying-rods, all of which have come down through the dark ages to modern times, sufficiently show their ancient origin, and that they are to be considered as a legacy from classic times.

The Caliph Haroun-al-Raschid caused many of the best writings of the Greeks, and, in particular, Ptolemy's "Almagest," to be translated into Arabic. About the year 1230 the first translation of the "Almagest" from the Arabic into the Latin language was made, under the auspices of Frederick II., Emperor of Germany. A knowledge of the Ptolemaic system of astronomy was thus diffused amongst the learned throughout Europe. The resuscitation of science was further greatly aided by the labours of Vinceus of Beauvais, Albertus Magnus, Roger Bacon, George Purbach, Johann Regiomontanus, Bernhard Walther, of Nürnberg, and Nicolaus Copernicus, of Thorn, all of whom devoted themselves to the study of nature in the thirteenth, fourteenth, and fifteenth centuries. Other philosophers now rapidly arose, the limited boundary of human knowledge became enlarged, until at length the true heliocentric theory of Pythagoras, so long overlooked, was again taught by Copernicus, and firmly established by the telescopic discoveries of Galileo.

Men of learning travelled into Spain, for the purpose of studying astronomy and mathematics in the Moorish universities. Arabian mathematicians discovered the value of the pendulum in regulating time, the properties of the magnet, and the mariner's compass. We are, above all, indebted to them for algebra, and for that system of arithmetical notation which makes the value of a figure depend upon its position. They were the founders of modern physical science, and in their pursuit of alchemy, endeavoured to investigate, for the first time, those secret forces of nature by which all material things are regulated and maintained. The Saracens form thus a connecting link between the new and the old eras. In their study of Greek literature they had anticipated the Western revival at the period of the Reformation; and by their Eastern origin they were the possessors of a culture to which Western Europe had not yet arrived.

The following passage well depicts the advancement of the Spanish Moors, at a time when the rulers of England, France, and Rome were living in houses without chimneys, and without glass to their windows. They possessed "palatial residences, which stood forth against the clear blue sky, or were embosomed in woods. They had polished marble balconies, overhanging orange-gardens; courts, with cascades of water; shady retreats, provocative of slumber in the heat of the day; retiring-rooms, vaulted with stained glass, speckled with gold, over which streams of water were made to gush; the floors and walls were of excellent mosaic. From the ceilings, corniced with fretted gold, great chandeliers hung, one of which is said to have contained 1,084 lamps. In the boudoirs of the sultanas, the furniture was of sandal or citron wood, inlaid with mother-of-pearl, ivory, or silver, or relieved with gold and precious malachite. Pillows and couches were spread about the rooms, which were perfumed with frankincense. In winter the apartments were hung with rich tapestry; the floors were covered with embroidered

Persian carpets. Through pipes of metal, water, both warm and cold, to suit the season of the year, ran into baths of marble, due provision being thus made for personal cleanliness. There were whispering-galleries for the amusement of the women, labyrinths and marble play-courts for the children, for the master himself grand libraries. The Caliph Alhakem's was so large that the catalogue itself filled forty volumes. He had also apartments for the transcribing, binding, and ornamenting of books." *

Intellectual Expansion of Europe.

The Crusades not only brought the Western armies into contact with Arab refinement, but also introduced them to a closer acquaintance than they had yet had with the lingering glories of Rome in the Byzantine Empire. With these wars the heavy clouds of religious fanaticism were dispelled and broken. The wealth of the towns increased, science revived, and more liberal thoughts were diffused throughout the breadth of Europe. Mankind no longer bore the intellectual chains imposed upon them. Blind submission to authority was exchanged for independent investigation and reflection. Europe was filled with inquiring and earnest men, some of whom, such as Wycliffe and Huss, even dared to be reformers of the Church itself. At length Luther appeared, and shook by his theses the very pillars of the Vatican.

* Draper's "Intellectual Development of Europe," vol. ii., pp. 30, 31.

PART III.

MODERN INDUSTRIAL ART.

INTRODUCTORY CHAPTER.

Influence of Geographical Discovery on Art—Progress of Mathematical and Physical Science—Introduction of Machinery, and Increase of Production—Improvement in Dwellings and Means of Communication.

THE IMPULSE GIVEN TO EUROPEAN ART BY GEOGRAPHICAL DISCOVERY.

THE close of the fifteenth century may be characterised as the age of geographical discovery. The Portuguese, Spaniards, Dutch, and English made successful exploring expeditions. Columbus landed on the Bahama Islands in 1492, and, in a later voyage, on the continent of America. A great stream of emigration has since been rapidly flowing thither, whilst Europe has been enriched with new animal and vegetable products. About this time, also, many discoveries were made in the Eastern Hemisphere which opened a world-wide market to industry, and gave a new impulse to every branch of handicraft. The overthrow of Spanish authority, the rise of English commerce, the French colonisation of Canada and the growth of population in the States of the American Union, the War of American Independence, and, above all, the French Revolution, constituted a succession of political events which materially

affected the welfare of the labouring communities of the world. The Atlantic seaboard now became the site of industrial activity, whilst the Mediterranean shores lost their old pre-eminence in commercial importance. New York and Havannah arose in the place of Genoa and Venice. The scanty supply of cotton which had hitherto been only imported from the East in limited quantities, was now superseded by the excellent and abundant cotton of American growth. From the new countries in both hemispheres were also received many novel and valuable food-plants, such as tea, coffee, cocoa, sugar, rice, Indian corn, and the spice plants. New dyes of the most exquisite tints also became known. Thus in 1570 indigo and cochineal, and in the seventeenth century Brazil-wood, and the preparation of carmine were introduced. In 1707 Prussian blue was discovered by Diesbach; in 1710 Saxon, and in 1775 Orleans blue. Dyeing had up to this time been practised merely in an empirical manner; now, however, the processes were based on chemical principles, Bergmann and Berthollet being the first to set the example. Under their lead, better kinds of mordants were employed; fresh tanning materials were obtained; many valuable woods, such as mahogany and ebony, were brought to Europe; and new and choice flowers, shrubs, and fruits were introduced into European gardens and orchards.

THE ADVANCEMENT OF SCIENCE.

The seventeenth century is remarkable for the progress of physical science and mathematics. The heliocentric theory of the universe, first successfully advanced by Copernicus, was established by Galileo, the founder of the science of dynamics, whilst Newton furnished its explanation by his discovery of the principle of universal gravitation. The invention of the telescope by Galileo, of the barometer by Torricelli, and of the air-pump and electrical machine by Otto von Guericke, the discovery of the velocity of light by

Römer, and of its polarisation by Huyghens, all indubitably mark this period as the "age of enlightenment." We ought not to omit to mention Napier, Newton, Descartes, and Leibnitz, distinguished in mathematics, Pascal in experimental philosophy, Kepler in astronomy, and Harvey in both physiology and medicine.

But most important of all, as regards industry, was the invention of the steam-engine, in the construction and improvement of which we meet with the names of the Marquis of Worcester, an Englishman (1663), Papin, a Frenchman (1680—90), Savery and Newcomen (1705), Leupold (the high-pressure engine, 1720), and lastly, James Watt.

Introduction of Machinery, and Increase of Production.

Since the application of steam, machinery driven by that motive power has, to a very great extent, superseded manual labour; and goods are made with a rapidity, regularity, accuracy, and finish unattainable by the most skilful and practised hand. With these advantages, it is important to remember how small, relatively to work done, is the number of workmen required. Upon Arkwright's loom, from 800 to 900, and even 1,000 threads can be spun at once, under the superintendence of one artisan, aided by a few children, whose business it is to tie broken threads. Other looms also display an increase of productive power. A ribbon loom will throw off from thirty to forty ribbons simultaneously, and the "Jacquard" is capable of executing both the simplest and the most complicated designs. Point lace and even embroidery are now made by machinery, as well as the fine tissue called tulle, the last being an invention, in 1807, of Keatkoth, an Englishman. Cloth-cutting and cotton-printing machines have also been constructed, and worked to considerable advantage.

Machinery has effected an equally astonishing revolution

in every branch of smiths' work. Thus the processes of casting, shearing, rolling, boring, sawing, punching, stamping, riveting, planing, and polishing are now all performed by mechanical aid. The shearing-machine severs an iron rod, one to one and a half inches in thickness, as easily as a tinman divides a thin latten plate with his scissors. A circular saw cuts hourly through 120 feet of dry oak an inch thick, a task to accomplish which without machinery would have required twenty-four men. By means of the rolling-mill, a square iron bar, an inch thick and two feet long, can be drawn out in less than a minute to thirty-two feet in length, and a quarter of an inch in thickness. The coining-press will stamp from forty to sixty coins per minute, whilst the pin-machine produces 100,000 pins in forty-eight hours. Machinery has been applied to engraving the most graceful devices on bracelets, seal-rings, and ornaments. There are also machines for copying reliefs and for imitating medals; machines for "turning" figures of animals, flowers, and arabesque work on watch-cases, boxes, &c.

Rapidity in production has had the effect of creating a continuous demand for raw material. Statistics clearly exhibit the march of industry and commerce. Europe consumes yearly 600,000,000 lbs. of wool, and 300,000,000 lbs. of flax, and French silks alone are annually manufactured to the value of £16,000,000. Gutta-percha and caoutchouc, so valuable for the numerous forms into which they can be worked, are annually imported to the extent of many millions of pounds.

The demand for metals, too, has been equally large. New alloys, such as argentine, have been discovered; and, by means of metallic plating, the precious metals are imitated. The art of working iron has especially developed itself, and iron has been applied to the manufacture of a greater variety of objects; articles of steel have likewise increased in demand enormously. The manufactures of glass-ware, porcelain, pottery, and cabinet-work have kept

pace with the improvements in other handicrafts, whilst the arts of lacquering and veneering have been perfected. Kitchen utensils of tin and iron are enamelled, and gilding is performed by the aid of galvanism. The improvements in chaises, wagons, mirrors, watches, and lamps can at present be only mentioned. The electric telegraph, photography, and gas illumination show in a striking manner the capacities of the human mind and the power of science. Lastly, we must mention the development of printing and the subsidiary art of paper-making, the revival of classical learning, and the growth of religious and civil freedom, as causes which have operated powerfully in aiding the growth of the busy industries of modern times.

The effects of this extraordinary intellectual and industrial activity are everywhere visible, too, in the changed aspect of the landscape. Land, once uncultivated field or forest, moor or marsh, is now a scene of rural industry,—of flower and fruit gardens, or of thriving farms. Instead of old rough paths over the inequalities of the surface, a network of good roads and railways extends in all directions. Numberless bridges span the rivers and streams. The old, narrow, dark streets of towns and cities have been widened, and thousands of well-built houses have been erected on the sites of dingy habitations.

Three nations, the Germans, the English, and the French, have co-operated in this rapid advancement, and in the commercial activity which has ensued. The Germans are unrivalled in their inventive powers, the English in their industry and in the colossal nature of their works, and the French in their taste, displayed in every branch of art. The Oriental nations, which gave birth to art and industry, have remained, as it were, stationary, or are, perhaps, becoming utterly forgotten: even Europe itself, apparently, is likely to be left behind by the great Western Republic. The natural resources of this growing power foreshadow a future of prosperity to which it is impossible to assign the limits.

CHAPTER I.

ARTS CONNECTED WITH THE SUPPLY AND PREPARATION OF FOOD, AND OF NUTRITIOUS AND STIMULATING BEVERAGES.

INTRODUCTION.

INORGANIC matter becomes first endowed with life and organisation during the growth of plants. The earth and the atmosphere are the two sources whence all sustenance is originally derived, and from which plants obtain the formative materials of their various tissues and fluids. The herbivorous animals, moreover, are as much food-products as the plants on which they feed; consequently, they form the food of the carnivorous races and in part of man. Thus nutritive matter circulates, slowly and gradually, through nature; thus it becomes endowed with life, and thus, by a gradual process of decay, it returns silently and imperceptibly to its original elements. Death is, in reality, the gate of renewed life. Not only the food, but the acts of digestion and assimilation, by means of which food is transformed, first into blood, and then into the various fluids and tissues of the body, are results dependent upon the operation of physiological and chemical laws.

Notwithstanding its great apparent variety, food, in its ultimate analysis, falls into four classes—viz., proteids, fats, amyloids, and minerals. The proteids are compounds of carbon, hydrogen, oxygen, and nitrogen, and include such food-stuffs as the albumen of white of egg, the syntonin of muscle and flesh, the casein of milk, the gluten of flour, &c. The proteids subserve the process of the formation of tissue as their special function, though they share with the next

two classes in maintaining the heat of the body. Fats contain but three of the four elementary principles mentioned above, nitrogen being absent. Their amount of hydrogen is more than sufficient to form water if combined with the oxygen of the compound. In this class are included all oils, the fat of meat, &c. Amyloids resemble fats in composition, except that the amount of hydrogen is but just sufficient to form water with the contained oxygen. This class includes sugar, starch, dextrine, &c. Fats and amyloids perform the function of maintaining animal heat. The three classes of food-stuffs already described are often called vital food-stuffs, because obtainable only from organic bodies. The fourth class includes such substances as sulphur, phosphorus, lime, and the salts of various alkalies and earths. One of the chief functions of this class of food-principles is to afford strength to the more solid parts of the animal frame.

With regard to the actual materials of diet, Nature furnishes man with the food most appropriate to each locality. Thus, in the arctic regions, much fat and oil are readily procurable, for these are heat-producing substances. In cold countries, where wheat cannot grow, oats and barley, the most heating cereals, grow rapidly and vigorously. So, also, man requires more animal food in cold climates than near the equator. In the sub-tropical and tropical regions vegetable matter is the most suitable food, inasmuch as it contains but little nitrogen, and is but slightly stimulating. Hence, in the zone of the tropics, we find produced in abundance rice, maize, sago, arrowroot, bread-fruit, and banana, together with numerous watery and mucilaginous fruits.

It appears that the white races attain the highest development and reach the greatest age above 40° N. latitude in the Western, and 45° in the Eastern Hemisphere; whenever they pass beyond these limits they deteriorate in health, and life is shortened. The mortality amongst Europeans in

India and other tropical countries is great. The question of the permanent occupation of such countries by Europeans is daily becoming increasingly important. One cause of mortality is, undoubtedly, the continuation of habits of life not so soon fatal in a colder climate.

SECTION I.—THE HUSBANDMAN.

Partial causes have, at various times, operated to check agriculture in Great Britain. Among these, the most pernicious was an old law which forbade any other animal than the ox being used to draw the plough, and which also compelled ploughmen to learn to make as well as to guide their own implements. Though the religious dissensions and internecine struggles which agitated England throughout the fifteenth and sixteenth centuries were detrimental to the immediate interests of agriculture, yet they brought about a change in civil and political institutions, and thus gave rise to the means and spirit of improvement, and contributed to the prosperity of succeeding ages. The gradual abolition of the system of villenage, the influence of the invention of printing, and the steady increase of population produced a perceptible effect upon agriculture; in the east and south, especially, the most active interest was taken in the cultivation of the soil. Landlords, for the sake of increasing their revenues, encouraged cultivation. Soils previously in a state of rude pasturage were tilled, and land already under cultivation was made more productive. From the Elizabethan period down to the present time the development of agriculture has been progressive, though irregular and unequal. Sir Anthony Fitzherbert, in "Ye Booke of Husbandrie" (1532), points out prevailing bad practices, and commends improvements which might be adopted by the agriculturist with advantage. The same work contains the first historical notice of manuring lands, and advocates the employment of marl for this purpose.

In England, before the seventeenth century, crops were small compared with what they are at present, and wheat was less cultivated than the inferior grains, oats, rye, and barley. Potatoes, carrots, turnips, &c., were unknown; but in the seventeenth century much more attention was paid to agriculture. The systematic repairing of roads, consequent upon the passing of an Act in 1663, facilitated the interchange of commodities, and opened up that great element of agricultural prosperity, an easily available market. Later on, Dutch engineers came from Holland to drain the east coast counties and other localities, bringing with them improved methods connected with the agricultural arts. A new form of plough, known as the Rotherham, was introduced by them into this country, and patented in 1730. It was afterwards improved by Small in 1740.

The rapid progress of agriculture in the present century has been the result of inquiry into its elementary governing principles; for so long as these were unknown it remained an empirical art. With the first true knowledge of the elements of nature, their mutual actions and relations, the real history of the *science* of agriculture commences; and our increased acquaintance with natural history, in its three departments, renders valuable assistance in establishing its fundamental principles.

The most perfect agriculture is that which produces, by the application of a given amount of labour, the largest and most permanent profit. This is obtainable by increasing the productiveness of the soil, and at the same time lessening manual labour through improvements in the mechanical appliances employed.

The means of increasing the productive power of land, which are partly chemical and partly mechanical in their action, may be summarised under the following heads :—

1. Supplying to the soil those organic and inorganic substances which it may require—the art of manuring.

2. Altering the texture, depth, and properties of the soil by mechanical means—the art of tillage.
3. Changing its relation with respect to moisture and temperature—the art of drainage.

The art of manuring land depends chiefly on two considerations—firstly, a knowledge of the inorganic constituents of the crop intended to be grown; and, secondly, a knowledge of the constituents of the soil. The soil must be able to supply the crop with mineral food, suitable in quality and quantity for enabling it to arrive at maturity. In every system of manuring, the chemical composition of the manure is that which constitutes its agricultural importance. The quantity of inorganic food drawn by the crops from the land is astonishing. Professor Johnston estimates that to restore the land to its original condition, it is necessary to add to each acre about fourteen hundredweight of mineral matter every four years. The constant removal of such large quantities of inorganic matter must in time exhaust the soil, and render it barren, unless restored by a judicious system of manuring. "In the hands of successive generations a field may so imperceptibly become less valuable that a century even may elapse before the change proves such as to make a sensible diminution in the valued rental. Such slow changes, however, have been seldom recorded; and hence the practical man is occasionally led to despise the clearest theoretical principles, because he has not happened to see them verified in his own limited experience, and to neglect, therefore, the suggestions and the wise precautions which these principles lay before him. General illustrations of this sure, slow decay may be met with in the agricultural history of almost every country. In none, perhaps, are they more striking than in the older slave states of North America. Maryland, Virginia, and North Carolina, once rich and fertile, by a long-continued system of forced and exhaustive culture, have become unproductive, and vast tracts have been abandoned to hopeless sterility."—*Johnston.*

"From every acre of this land were removed, in the course of a century, 12,000 lbs. of alkalies, in leaves, grain, and straw."—*Liebig.*

Manures are now drawn from each of the three natural kingdoms; and during the last quarter of a century, means have been devised to render available as food for the plant, waste products of various kinds, which hitherto have been unapplied.

The art of tillage has in our days attained to great perfection, by improvements in agricultural implements: these have, moreover, economised labour to a marvellous extent. Tillage operations are generally carried on by horse-power, but, of late, steam has been made practically available, and has proved of immense service to the farmer.

The art of drainage was practised by the Romans, and till even within the last century had undergone no modification. The only method consisted in the mere removal of superabundant moisture. The modern art dates principally from the methods introduced in 1764 by Elkington, which chiefly consist in adapting the depth, capacity, and construction of drains to the variations in the texture of the subsoils. Though this department of farming is based on well-ascertained physical laws, yet our own island still contains thousands upon thousands of acres of land more or less unproductive through the want of it.

Steam has now obtained a firm footing in agricultural operations. It has been used for many years in the millwork of farms, in threshing, grinding, chopping, and cutting. But its application to the preparation of the soil was less simple, and it is only within the last twenty years that much progress has been made in this direction. In some of the earliest designs, it was proposed to move the steam-engine along with the ploughs or cultivators, thus entailing a great waste of power. The best plan is now found to be to keep the engine and head-gear stationary at one headland of the field, only moving it occasionally, as required for conve-

nience, and to transmit the power to the ploughs by ropes. The ploughs form a double set, of two or three in number, one set being brought into action when the framework which carries them is moving in one direction, the other set when it is proceeding in the other direction. There are other methods, besides many modifications of this. Various reaping-machines have been invented since 1812. The principle of that of 1830, by Bell, is adopted in most of those used in this country and America. There is a great similarity in all of them, and they require the sheaves to be bound by hand. Reaping-machines, to be successful, must have the land fairly level and free from large stones, since the ridges, which are no detriment to hand-reaping, are impediments to machines. The abandonment of ridges will render underground drainage even more necessary, and therefore improve the land.

SECTION II.—THE MILLER, BAKER, PASTRYCOOK, AND CONFECTIONER.

Since the Mediæval Period, each of these branches of industry has advanced. In the mode of obtaining and preparing flour great progress has been made. It is necessary to effect a separation of the bran, &c., before the pure flour is obtained. The old bolting-mill formerly used for this purpose—a sort of bag made of a peculiar kind of open canvas, into which the meal was thrown—has since been superseded by the dressing-machine; the flour in consequence is whiter and purer. A Mr. Bovill has recently invented other improvements. By the old plan, the flour scattered by the centrifugal force as it issued from the stones filled the atmosphere, causing much loss of material as well as injury to health. Now, however, by the stone being completely boxed in, the scattering is prevented. A continuous blast of air is directed between the stones, which hinders the flour from being overheated, and removes, at

the same time, every particle that is formed. The air of the mill is thus kept free from annoying dust, the former waste is avoided, and the colour of the flour perceptibly improved. By the aid of steam, eight bushels of wheat can be ground per hour in place of four. In consequence of these improvements, to which very much attention has been paid in the United States, a vast trade in flour has arisen between Europe and America. In New York there are mills which grind, sift, and pack 800 barrels of flour in twenty-four hours.

Machinery is also employed in the making of bread. M. Rolland, of Paris, has invented a simple and easy-working kneading apparatus, by means of which a sack of flour can be converted into well-made dough in twenty or even ten minutes. The late Dr. Dauglish produced his aërated bread by machinery, using carbonic acid instead of yeast. This bread is light and wholesome, and the process cleanly, from the fact that neither the hands nor the feet of the baker come into contact with the dough. The art of making and baking bread advances slowly in England, owing to the opposition of the bakers and the prejudices of the people. In other nations bakers have long since availed themselves of steam-power and machinery. Mr. Perkins has invented an oven which is heated by hot water-pipes. Machinery has also been invented for making biscuits,—mixing the ingredients, kneading the dough, and cutting and shaping it into the requisite form.

Gingerbread making and confectionery are now separate departments of the baker's art. By means of a knowledge of the arts of boiling, clarifying, candying, crystallising, bleaching, and sugar-refining, any fruits may be preserved, without loss of their flavour, in a transparent syrup of a proper consistence, which penetrates into every part of the fruit, and prevents the natural decomposition that would occur. The Greeks and Romans, although probably otherwise acquainted with the sugar-cane of Asia, chiefly used

honey as a sweetener. Herodotus speaks of certain bees "which make a great quantity of honey," and satirically adds, "Confectioners make much more." In the house of every wealthy citizen there was a *pistor dulciarius*, or baker of sweet things; and several bronze moulds, evidently used by Roman pastrycooks for making sweetmeats, and representing hearts, animals, and striated shells, have been found in the ruins of Herculaneum. Pliny recommends that quinces should be boiled in honey, and directs that other sorts of fruit should be preserved in wax.

Dioscorides, who lived in the first century, is the earliest author who mentions sugar by name; while nearly at the same time Pliny, in his "Natural History," speaks of the "reed honey, called σάκχαρι." It was, from its first introduction to a comparatively recent period, restricted in its use to physicians and apothecaries, who employed it in making sweet compositions, under the general title of confections, hence the term confectionery. In the thirteenth and fourteenth centuries, "those were often called apothecaries who, at Courts and in the houses of great people, prepared for the table various preserves, particularly fruit encrusted with sugar, and who on that account may be considered as confectioners."* In Germany, in the fifteenth century, it appears that no suspicions were ever entertained of apothecaries becoming rich by their profession, for we are expressly told that they were allowed many other advantages, particularly that of dealing in sweetmeats and in confectionery. They were licensed to prepare confections and cooling drinks for the sick, and in some places were required to supply the Court or the town-council with goods, or "goodies," in return for which they were granted certain exclusive rights and municipal privileges.

It is probable that such precedents on the Continent originated the English practice in the sixteenth century of presenting to royalty rich boxes of sweetmeats and orna-

* Beckmann's "History of Inventions," vol. i., pp. 328, 329.

mental devices in pastry. In 1562, Queen Elizabeth of England was presented on New Year's Day "by Revell, surveiour of the works, a marchpane, with the modell of Powle's church and steeple in paste. By John Hemingway, poticary, a pott of oringe-condytt, a box of pyne-comfytts musked, a box of manus-christi, and lozenges." *

After the discovery of America, sugar became more abundant and cheap, and the confectioner's art ceased to be confined to apothecaries. In modern times, confectionery is manufactured in vast quantities, and with great skill. Fruits, such as peaches, apricots, apples, pears, plums, and walnuts are now preserved in the greatest perfection, whilst every variety of jelly, jam, ice-cream, water-ice, comfit, and bonbon is prepared in a most attractive style.

In Prussia alone there are more than 2,000 persons engaged in this trade. In the United Kingdom it is carried on yet more extensively. It is estimated that upwards of 150 tons of sugar, valued at £366,600, are every week converted into confectionery. England is also celebrated for its preparations of strawberry, raspberry, and gooseberry jellies. The English wedding-cakes form an important article in this department, being sometimes constructed of enormous dimensions, and sold at prices varying from a few shillings to £150.

The greatest advance in the art of confectionery has, however, been made by the French. The trade forms an important part of Parisian industry, not only on account of the numbers to whom it furnishes employment, but also by reason of its connection with other branches of trade. The labours of the artist, lithographer, dyer, varnisher, paper-manufacturer, pasteboard-maker, engraver, gold and silver beater, manufacturer of stamped articles on coloured paper, and the silk-weaver are all necessary to produce the ornamental and fancy boxes in which the choice bonbons and

* See "Confectionery," Reports by the Juries, 1851, Class xxix., p. 537.

fruits are packed. Paris has been for years the centre of this trade, and the taste displayed in the manufacture of the boxes, to say nothing of the superiority and perfect preservation of the fruit, has given it quite a monopoly.

The superiority of French chocolate is owing to the machinery employed in grinding and triturating the material. A great variety of objects are cast in moulds, made of sheet-copper, and hammered to the required shape. The subjects selected are always covered with a preparation of sugar, or, as it is called, glazed, and coloured to represent nature as nearly as possible.

The tarts, buns, biscuits, cakes, and numerous varieties of fancy-bread and pastry, which form so large a proportion of the articles displayed in the "sweetstuff" shops, do not properly belong to this branch of trade, but rather to that of the pastrycook, whose business, however, is more often than not combined with that of the confectioner.

The cheap confectionery sold in the inferior shops of England is sometimes coloured with dangerous mineral poisons. Gamboge, lead, copper, mercury, vermilion, emerald green, chromate of lead, and bisulphate of mercury have all been detected in the colouring ingredients. The health and lives of the children who eat these sweetmeats are thus endangered. In France this evil has been corrected by legislation. Scientific chemists have been employed to report on the harmless matters which can be substituted for these poisons. The following is a list of colouring matters allowed by the late Imperial Government: —"For blues—indigo dissolved in sulphuric acid, Prussian blue, or preferably, ultramarine; for reds—cochineal, carmine and carmine lake (provided it contains no vermilion), and Brazil-wood lake; for yellow—saffron, Persian berries and French berries, quercitron, turmeric, fustic, and the aluminous lakes of these substances; for greens—a mixture of the various yellows and blues, but no kind of emerald green, as it is a virulent poison; for violet—logwood alone,

or mixed with Chinese blue in various proportions; and for pansy-colour—carmine and Prussian blue, or carmine and ultramarine, in various proportions."*

SECTION III.—THE GRAZIER AND THE BUTCHER.

Since the Middle Ages no progress has been made in the butcher's art. The present mode of killing is at once cruel and barbarous, and a more humane method has yet to be discovered. The Mosaic Law so strictly forbids the eating of blood that butchers amongst the Jews must be licensed by the rabbi before being allowed to slay for the synagogue. The Hebrew butcher does not kill by a blow, but by tying the limbs of the beast, throwing it upon the ground, and then dividing the large arteries of the neck. The blood in this manner becomes completely discharged. The bones of each separate joint are then marked with Hebrew characters, after which the meat may be lawfully eaten.

The grazier's art, on the contrary, has greatly advanced. Valleys, once unhealthy swamps, and hills and mountain slopes, once covered with barren moors or forests, have been reclaimed from a state of nature by skilful agriculture, and are now covered with herds of cattle. The animals, too, have been greatly improved by cross-breeding, while their feeding and fattening are conducted on well-ascertained principles. The English cattle are most esteemed, next the Dutch and Swiss breeds; and in Germany, the Polish, Hungarian, Ukraine, and Moldavian races. An impulse has been given to sheep-farming throughout England and the Continent by the importation of the Merino breed from Spain; swine, also, have been improved on the Continent, through crossing with superior English stock.

* See "Confectionery," in "Cyclopædia of Useful Arts and Manufactures." Edited by Charles Tomlinson.

Modes of Preservation of Meat.

The important discovery of the art of preserving meat fresh and good for an indefinite period, in air-tight canisters, has tended to develop the grazier's and butcher's trade. The value of this discovery—a result of the progress made by chemical science—cannot be over-estimated. As other modes besides the exclusion of the air are adopted, we shall first briefly notice them and the chemical laws on which they are based. Meat is preserved—

1. *By Smoking.*—The efficacy of smoking depends on certain chemical products disengaged during combustion, such as pyroligneous acid and creosote; the latter substance possesses the property of coagulating albumen. Smoke from the twigs of juniper, and from rosemary, peppermint, and other fragrant herbs, imparts to the meat an aromatic flavour. The superior excellency of the Westphalia hams is owing to their being impregnated with juniper. Slow is better than rapid smoking, because the smoke penetrates the meat more completely.

2. *By Ice.*—We have a remarkable instance of the preservation of meat through the effects of cold in the discovery made by Pallas, 1779, of an enormous mammoth embedded in the ice-cliffs on the shores of the Arctic Ocean. Its organisation was uninjured, and the wolves and foxes preyed upon its flesh for weeks. Here the exclusion of the air, combined with a low temperature, had prevented putrefaction. In Canada, Hudson's Bay Territory, and other sub-arctic countries, frozen meat is a common article of commerce. In the stores of St. Petersburg may be seen, during the greater part of the year, partridges from Saratov, swans from Finland, heathcocks and grouse from Livonia and Esthonia, and trap-geese from the steppes of Tartary. These birds, as soon as the life-blood has ceased to flow, are apparently converted into stone by the frost. They are then collected, packed in huge chests, and forwarded to market for sale. Fish of all kinds, especially

salmon, are packed in ice, and regularly sent during the season to London. Most fishmongers are furnished with icehouses, or cellars, in which fish are kept. In the north of the United States, where ice is usually plentiful, it is largely collected, and used for preserving meat and fish. In the Southern States, icehouses are kept by the butchers, to which their meat is sent as soon as killed. It remains through the night in cells, in which it is cooled down to the freezing-point. On the following morning it is exposed for sale. Its low temperature is retained so long that under the burning sun of South Carolina there is less loss than in our own country.

3. *By Drying.*—By the North-American Indians the flesh of the buffalo, bison, and deer is cut into thin slices, and is dried in the sun, the fat having first been removed. This tough, dry meat, called "pemmican," does not putrefy. Captain Parry used it in his polar expedition, with this difference, that the pemmican was pounded, mixed with fat, and potted. Kept from the air, it could be preserved for several years. Jerked beef is prepared in South America and the West Indies by cutting the meat into narrow strips, immersing it in sea-water or brine, and then drying it in the sun. Cod, ling, haddock, and other products of our northern fisheries are simply opened, soaked in brine, and dried in the air.

4. *By Preserving in Salt and Sugar.*—These substances possess antiseptic properties. There are two methods of salting; in one the meat is packed in dry salt, in the other it is immersed in brine. Professor Morgan, of Dublin, has recently proposed a method of preservation by injecting into the animal as soon as killed a fluid preparation, consisting, to every hundredweight of meat, of one gallon of brine, half a pound of saltpetre, two pounds of sugar, half an ounce of monophosphoric acid, and a small quantity of spice. To test this principle, he has established several factories in different parts of South America. The Ad-

miralty, also, have had his plan under trial for several months, and the officers who have tested it report favourably on it. Sugar, like salt, absorbs the water in the meat, and thus prevents decomposition. Hams and fish are frequently sugar-cured.

But the most scientific and enduring method, and, therefore, that most generally adopted, is that of excluding air from the meat. The body of either man or animal, as soon as life has departed, becomes subject to the laws of chemical decomposition. The changes popularly known as decay and putrefaction all result, as shown by Liebig, from the absorption of oxygen, which produces first decay, then putrefaction. The success of the modes of preserving meat by smoking and drying depends on the evaporation of water; salt and sugar effect the same object by absorbing the water, and cold by solidifying the juices. If, however, oxygen be excluded from the meat, it is obvious that the decay which precedes putrefaction will be prevented. The exclusion of air is, therefore, the most scientific and efficacious method of preservation.

The process of M. Appert, as modified by Messrs. Donkin and Co., which is described in "The Natural History of Commerce," p. 287, is now extensively used in Australia and South America. It consists in enclosing the parboiled meat in hermetically-sealed canisters, from which all the air has previously been driven off. In this manner beef, mutton, veal, pork, poultry, fish, game, soups, and broths, as well as vegetables and fruits of all kinds, may be preserved, in any climate, for any length of time, without fear of putrefaction. An incalculable benefit has thus been conferred on commerce; privations and sufferings, such as those of our forefathers, have been prevented, and the mariner is no longer restricted to salt meat in his diet. The consumption of preserved meats is enormous; thousands of tons are required for victualling the shipping in our harbours, besides the immense quantity

which we send to the East Indies and to our colonial possessions. A large supply, too, is setting in to this country from districts in which flesh-meat is superabundant.

SECTION IV.—THE GARDENER.

For a long time it was thought impossible to discover the origin of those vegetables commonly cultivated for food. The most ancient traditions supposed that they were derived from miraculous intervention, and that the cerealia were the gifts of the gods. The progress of geographical and botanical researches has, however, dissipated all delusion. Olivier and Bruguières, in travelling through Western Asia, the cradle of the human race, discovered wild rye and barley; and M. Alphonse de Candolle gives a list of 157 plants selected as the most commonly cultivated, eighty-five of which are also found in a wild state. Our best naturalists, therefore, are now agreed that all our kitchen-garden plants, as well as our cerealia, have originally descended from some wild form.

We have already seen to what extent the ancients cultivated the food-plants now in use. Ornamental plants are also valuable for the pleasure which we derive from their beauty and fragrance. In the sixteenth century a new impulse was given to horticulture in Italy. A garden commenced at Pisa, A.D. 1544, by Cosmo de Medici, on the banks of the Arno, was, in 1555, through the exertions of his successors, Lucas Ghini and Cæsalpinus, enriched with the plants of Greece, Egypt, and the Levant; and public gardens were also formed at Bologna, Lucca, Naples, Florence, and Verona.

From Italy the art of gardening extended to Germany, and naturally enough to those places where the greatest wealth was collected. Augsburg became the school of German gardening. Ambrosius Hochstetter, a rich merchant, planned the first pleasure-grounds, viz., a garden devoted

exclusively to the cultivation of ornamental trees and flowers. It was much admired for the rarity of its plants, the beauty of its summer-houses and lakes, and especially for the extraordinary skill which was displayed in its water-works. Similar gardens were established in Nürnberg, Ulm, and many other places. Horticulture, in fact, began, in the sixteenth century, to be everywhere prevalent in Germany. Tulips were introduced from Constantinople, and first bloomed in the beautiful grounds of Heinrich Herwart, in 1559.

Gardening at this time, was equally encouraged in Austria, under the Emperor Maximilian II. and his son, Rudolph. Duke Christopher created a taste for it in Suabia. A garden laid out subsequently at Stuttgard, in 1578, is said to have been the finest in Germany, and was extolled even abroad. In England, about this time, our gardens were only scantily supplied with either flowers, fruits, or vegetables. The fruits grown were chiefly gooseberries, currants, strawberries, apples, pears, plums, and cherries, all of an inferior quality. It was not, says Hume, till the end of the reign of Henry VIII. that any salads, turnips, carrots, or other edible roots were produced in England. The little of these vegetables that was used was imported from Holland and Flanders. Queen Catherine, when she wanted a salad, was obliged to dispatch a messenger thither on purpose. The king ultimately sent for a Dutch gardener, who cultivated the materials for the queen's salad and the common kitchen vegetables, in the king's garden.

The discovery of America, and of the passage to India by the Cape of Good Hope, gave an impulse to gardening, and it became necessary to erect green and hot houses for the shelter and culture of the rich and rare fruits and flowers received from tropical countries. Forcing-beds, made of tanner's bark, were introduced into the system of gardening by the Dutch, and were first employed in England, in 1688, at Blackheath, in Kent, for the rearing of orange-

trees. According to Mr. Loudon, greenhouses were first invented by Soloman de Caus, architect and engineer to the Elector Palatine, who constructed the gardens at Heidelberg in 1619: one in the apothecaries' garden at Chelsea is mentioned by Ray, in 1684. But buildings of this description are doubtless of far greater antiquity.

Since the invention of glass roofs, gradual improvements have been made in greenhouses, particularly in the obstruction of the *heat-rays*, to which the scorching of plants was especially due. The modern plan of arched roofs, supported on iron girders, is, in another respect, a great success, for it presents an obstruction to light amounting to only one twenty-third or one twenty-seventh, instead of the former loss of one-seventh, or even one-fifth. Improvements have also been effected in the mode of heating. Steam or hot water pipes, which afford the gardener the power of modifying the moisture of the greenhouse, have been substituted for the stoves and hot-air flues which formerly filled the building with gaseous exhalations prejudicial to the plants.

In connection with this subject, it only remains to direct the attention of the reader to a few of the commonest and most interesting ornamental flowers and trees cultivated in the greenhouse,—to mention the countries where they grow spontaneously,—to give a brief account of those scientific improvements and inventions which have brought the art of gardening to its present state of perfection, and to describe a few gardens deserving of notice.

The tuberose, a native of the East Indies, was brought to Europe, in 1594, by Simon de Tovar, a Spanish physician, who is also accredited with the introduction of that most beautiful ornament of our gardens, the belladonna lily (*Amaryllis formosissima*), a native of South America. Maize, yam, tobacco, and the pine-apple were brought to Europe by the Spaniards, towards the end of the sixteenth century. Our geraniums are all natives of the Cape of Good Hope.

From India we received, in 1780, the Bengal rose, which is the stock of all our monthly roses, together with the balsam (*Impatiens balsamina*). China has sent us, besides her tea-plant, the orange, the mulberry, and the Chinese primrose. The first China-aster bloomed, in 1728, in the botanical gardens at Paris. Japan has contributed the beautiful camellia and the yellow Japan rose (*Corchorus Japonica*); Egypt, the mignonette; and the countries around the Mediterranean, the oleander, olive, peony, lavender, crocus, hyacinth, narcissus, and box. The first species of dahlia known to Europe was discovered in Mexico by Humboldt, in 1789, and sent to the botanical gardens at Madrid. The beautiful cypress vine, the balloon vine, the zinnia, and numerous species of cacti also came from Mexico. From North America have come the magnolia, tulip-tree, poplar, rhododendron, azalea, rudbeckia, golden-rod, sunflower, and arbor-vitæ; from California, the eschholtzia and verbena; and South America has given us the fuchsia, calceolaria, heliotrope, lupine, tropœolum, vanilla, many beautiful orchids, the begonia, agave, passion-flower, and the splendid Victoria-regia water-lily. Africa has contributed to our hothouses many heaths and pelargoniums, the mesembryanthema, or ice-plants, the fig, gladiolus, stapelia, and numerous species of oxalis, acacia, and mimosa. All our weeping willows are descended from a branch of *Salix Babylonica*, which Pope received in a basket of figs from Smyrna, and planted in his garden at Twickenham. Our Australian colonies have also added largely to our cultivated flora, supplying us with the beautiful *Epacridaceæ*, or Australian heaths, and some noble tree-ferns, besides many myrtaceous plants and valuable evergreens. Beautiful Alpine plants have been received from Switzerland, the mountains of North America, and the Himalayas. The common garden auricula was brought originally from the snow-covered mosses of the lower Alps. There, also, is the home of the sky-blue gentian, and the Alpine ranunculi, anemones, veronicas, and saxifrages.

Previous to the time of Linnæus, the phenomena of fructification in plants were little understood. The labours of Grew, Malpighi, Knight, Bonnet, and Du Hamel opened up a new aspect to gardening, and placed it on a scientific basis. The mode of producing varieties by artificial fertilisation has been brought to its present state of perfection through the labours of Jussieu, Endlicher, Robert Brown, Lindley, and De Candolle. The systematic labours of the last-named naturalist have been to botany what Cuvier's researches have been to anatomy, and his classification of the vegetable kingdom is now generally adopted. Another class of philosophers — among them chemists, who have specially directed their researches to the vegetable world—and who have contributed to the advancement of scientific horticulture are such men as Jupenhous, Priestly, Tennebier, Schrœder, Saussure, Johnson, and Liebig, who have, by their united labours in the chemistry of vegetation, not only proved that plants breathe, feed, and digest, but have clearly shown how vegetable respiration, feeding, and digestion are conducted.

It was not until after the invention of the microscope that even an imperfect knowledge of vegetable anatomy and physiology could be gained. The instrument used by Grew, Malpighi, and other early investigators has been replaced by microscopes of far higher powers. Chemical analysis is now applied to the tissues of plants, with no small amount of success, and continual additions are being made to our knowledge of vegetable structure.

The most important gardens on the Continent are those of Munich, Berlin, Vienna, St. Petersburg, and the Jardin des Plantes, at Paris. The emperors of Austria have for more than a century been anxious to render their garden at Schönbrun superior to any other in Europe. This garden excels chiefly in tropical species from South America.

The gardens at St. Petersburg, founded by the Emperor Alexander, have immense glass houses, rivalling even the

noble palm-house at Kew and the imperial structures at Schönbrun. In the severely cold climate of Russia, it is indeed a triumph to have so overcome the difficulties of nature as to grow the most beautiful and fragrant flowers of the tropics—the tree-fern, the lofty cabbage-tree, and the cocoa-nut palm—during the depths of an arctic winter. In the open air there is an arboretum, and a large collection of hardy plants, one division of which is devoted to medicinal plants, the other to illustrations of systematic botany. The most striking feature in this collection is the geographical arrangement.

The Jardin des Plantes, the largest public garden in France, is a natural history collection of both animals and shrubs. The botanical part was commenced in 1626, by Louis XIII., and opened in 1650. For a long while it consisted only of grounds laid out according to the system of Jussieu, and of a very indifferent collection of hardy herbaceous plants and trees. The conservatories and hothouses recently erected are greatly inferior both in size and contents to those at Kew; but the garden contains an admirable botanical museum, a collection of woods, vegetable products, and fossil plants.

It has been the general policy of the English Government to encourage science and art only indirectly. This duty, therefore, has been of necessity thrown upon the people. Hence, while we have a magnificent collection at Kew, there are more public and private gardens in the United Kingdom than in any other country in the world. Besides the large botanical gardens at Liverpool, Cambridge, Oxford, Glasgow, Edinburgh, Dublin, and London, there are fine public gardens in Sheffield, Manchester, and Birmingham, not to speak of splendid private collections belonging to horticultural societies, to our nobility and gentry, and to enterprising nurserymen, seedsmen, and florists. The Royal Botanic Gardens at Kew contain a good selection of Australian, New Zealand, and Himalayan plants, a museum

of economic botany, an extensive herbarium of 180,000 species, very spacious hot and green houses, and a noble palm-house 362 feet long, 100 feet wide, and 66 feet in height. During the twenty years' war which succeeded the French Revolution, these gardens were almost the only spot in Europe where exotic plants could be received in any quantity, and they have been the direct channel through which Europe has received many new species.

The flourishing condition of horticulture in Great Britain and Ireland was exemplified by the magnificent display of cultivated plants at South Kensington, in May, 1866, at the meeting of the "International Horticultural and Botanical Congress." Formerly naturalisation was more the result of individual undertakings, or of the operation of natural diffusion, than of regularly planned scientific labour. Thanks, however, to men of broad views, societies have been formed for the purpose of naturalising both plants and animals by scientific care, and by crossing the foreign species with home breeds. France is taking the lead in this matter, and at Paris acclimatisation gardens have been laid out which have acquired considerable renown through the success which has already attended them.

SECTION V.—THE BREWER.

When wearied with bodily or mental exertion, man seeks relief either in repose or in the use of soothing or stimulating beverages; hence narcotic and stimulating liquors have been brewed by almost every people and nation. *Pulque*, the fermented juice of the aloe (*Agave Americana*), is the favourite drink in Mexico. *Quass*, a stimulating liquor made by the fermentation of rye and barley flour, is the popular beverage in Russia. In warm climates the juice of various species of palm is extracted and fermented; and we find Herodotus speaking of palm wine as one of the principal articles of commerce in ancient

Babylon. With the ancient inhabitants of Scandinavia and Britain, *metheglin*, or *mead*, was the favourite drink. An intoxicating liquor called *bhang*, prepared from the leaves of Indian hemp (*Cannabis Indicus*), is drunk by the natives of Hindostan, and is much used throughout Persia and Arabia. But the beverage most popular at present in European and American countries is the fermented infusion of barley-malt and hops, popularly known as ale, beer, or porter—a liquor both stimulating and nutritious, from the spirit, sugar, and mucilage which it contains; and soothing and strengthening, from the hops, which possess both narcotic and tonic properties. Hops were brought into England by the Flemings about A.D. 1524; and Du Royle notices as a curious fact that soon after their introduction they were petitioned against by the Common Council of the City of London, on the ground that they would spoil the taste of drinks and endanger the health of the people. In consequence of this, Henry VIII., in 1530, ordered not only the servants of his household, but the brewers everywhere throughout England, not to put any hops or brimstone into the ale! This prejudice appears to have died away in the reign of Edward VI., for hops were then cultivated; and from an Act of Parliament in the first year of James I., 1603, we learn that they were produced in abundance in England. From that period to the present, the art of brewing has progressed in proportion to the increase of population.

In the earlier part of the eighteenth century, Mr. Combrune, a practical London brewer, in a work entitled "The Theory and Practice of Brewing," showed the value of the thermometer in regulating the temperature of liquors in their progressive stages. The saccharometer, by which the specific gravity or density of the liquid extracted from the malt is determined, was first brought under the notice of brewers by Mr. Richardson, of Hull, in 1784. These were the first steps in the application of science to brewing.

The changes which take place in the barley, by which it is transformed into malt, as well as every change in the infusion of barley, malt, and hops during the various courses of mashing, boiling and cooling, fermenting, and fining or clearing the liquor, are now clearly understood, in consequence of the investigations of Gay Lussac, Vogel, Saussure, Brande, Ure, Payen, Thompson, Liebig, Johnson, and other chemists. Science has also explained many causes of failure in both the malting and brewing processes, and has laid down precise rules for the successful conduct of the operation. The varieties of malt used in brewing, known as pale or amber malt, brown or blown malt, and roasted or black malt, are produced simply by change of temperature. The first alone is used for the best ales, the second for porter or stout, and the last for the procuring of a deep and dark colour. The pale or amber malt yields the saccharine, or fermentable extract; in the brown and the black malt the extract is not fermentable, the sugar being wholly converted into gum.

Porter was used as far back as 1730. Before that period the malt liquors were ale, beer, and "twopenny." It was usual for the landlord to combine either of these in a highly popular drink, called "half-and-half," which consisted of either half ale and half beer, or half ale and half twopenny. Another beverage, called "three threads," was also in demand, and consisted of a mixture of ale, beer, and twopenny, in equal proportions. In the same year (1730) Mr. Horwood, a brewer, conceived the idea of making a liquor which should combine the flavour of ale, beer, and twopenny. His operations were successful, and the desired drink being produced, was called by him "entire," or "entire butt beer;" meaning that it was drawn entirely from one cask or butt. Being regarded as a hearty, nourishing liquor, it was thought suitable for porters and the large class of mechanics whose occupations require considerable bodily strength. Hence the term "porter."

New methods have been invented for drying and grinding malt, improved mashing machines have been patented by Steele, and a large cooling apparatus and cooling tubes by Sankey, an Englishman. Fresh expedients for promoting fermentation have been discovered, together with instruments for accurately determining the degree of concentration of the wort. Lastly, steam-engines have been employed, and found to act admirably.

The appliances of modern science are well illustrated in a large brewery in Spitalfields, which covers nearly six acres of ground. In this establishment steam has been brought so extensively into use as to supersede human labour to an extent which is truly astonishing. Ten engines, great and small, exert in the aggregate a force of 200 horse-power. Steam, in fact, does everything with the single exception of pulling the barrels up an inclined plane, which is performed by a small engine worked by electricity. Steam lifts the malt from the wagon into the lofts, by means of a Jacob's ladder, or collection of little boxes a few feet apart, working upon an endless gutta-percha chain. These boxes carry aloft 120 sacks per hour. Steam turns the Archimedean screws concealed in wooden cylinders, which in their course convey the descending malt from one floor to another, distributing the same, where required, throughout the lower rooms. Steam also crushes the malt between revolving steel rollers, pours it with the boiling water from the coppers into the mash-tuns, and turns both the old huge-armed revolving spindle, and the new and smaller, but far more effective steel masher. It is by steam, too, that the hops are poured into the boilers, transferred from one boiler to another, and when exhausted, compressed and mixed with the coal for fuel. The fires themselves are fed by slowly-moving machinery. Besides all this, steam pumps the boiling beer from the coppers to the coolers—large, shallow pans, in the highest and best ventilated rooms in the building, in which the beer is spread out over a super-

ficial area of 32,000 square feet. Nay, it does more, it raises cold spring water from artesian wells sunk 520 feet deep into the chalk to the height of the coolers, and causes it to circulate through the tubes of refrigerators, by contact with which the temperature of the beer is still further reduced. The empty casks received from the taverns are partially filled with gravel and water, placed eight at a time in a rotatory machine, and cleansed by steam, the same agent being employed to rinse them. Many of the improvements of this establishment are only of recent date, and have originated on the premises. For the large circular vats in which the ale was formerly fermented, slate tuns have been recently substituted; whilst, for other purposes, square vessels of slate have taken the place of circular casks. The number of barrels in use by this firm is 80,000, which, if placed end to end in a straight line, would form a row forty-five miles in length. To convey these barrels to customers, 130 powerful horses are needed, worth on an average £70 each.

Much of the beer retailed by the public-houses in London and throughout the United Kingdom is grossly adulterated. It has been ascertained by chemical analysis that quassia, gentian, wormwood, and broom-top are added to impart bitterness; capsicum, ginger, coriander, orange-peel, caraway, to give pungency; opium, cocculus Indicus, nux vomica, tobacco, poppy, henbane, to intoxicate; molasses, sugar, treacle, as substitutes for malt; sulphuric acid, alum, and salt, to impart other properties. Some items in this numerous list are generally to be found.*

In Germany, where hopped beer had its origin, Bavarian beer was most esteemed. It is not only consumed in Saxony and on the Rhine, but is exported to Copenhagen, Naples, and Athens, and even to the most distant parts of the world. This ale owes its excellence to the careful inspection of

* See "English Encyclopædia," by Charles Knight (Article, "Brewing").

breweries by Government authorities. A large quantity of Bavarian beer is consumed in Germany, and in many provinces it has entirely superseded the use of wine. The duty thereon is a source of very considerable public revenue, amounting annually to several millions of florins.

SECTION VI.—THE INNKEEPER.

In the early dawn of civilisation inns and hotels did not exist. Natural barriers to international commerce and social intercourse, created by difference of language, by intervening seas, oceans, deserts, and mountain-chains, formerly existed in all their force. There was no steam, no mariner's compass, no telegraph wires. The roads were but the rudest footpaths, which led the traveller in a nearly direct line over the surface of the ground. Private hospitality was, therefore, a necessity, and to refuse it to a stranger was a crime.

Without the facilities for business which good roads supply, the large towns and cities of modern times could not exist. In fact, a complete network of well-constructed roads is as necessary to the strength of a nation as the veins and arteries to the health and nourishment of man.

Caravanserais, the oldest inns on record, were at first only unfurnished huts, where travellers could find shelter and water, but not food. Others were afterwards built by wealthy and pious Mahommedans, where hospitality was offered gratuitously, in order to facilitate the pilgrimages to Mecca. These last were well supplied with food as well as water, and travellers could obtain stalls for their camels, mats, carpets, and other conveniences. In modern times such caravanserais have been erected in towns and cities, as at Cairo, Damascus, Aleppo, and Beyrout. They are large and handsome, and are well furnished with everything that an Eastern traveller requires. They are either the property of private individuals, or belong to the mosques or the Government.

We find that the Romans were the first road-makers in Great Britain. It is true that their object was to keep the people in subjection by facilitating the movements of their armies; but the benefit conferred on the country, if unintentional, was great. After their withdrawal from Britain, the highways fell into decay, and for several centuries intercourse was chiefly carried on by means of the rudest paths.

In the Mediæval Ages, before turnpikes were constructed, the castles of the barons and the monasteries of the abbots offered shelter and food to the passing traveller. The baronial arms were always hung in front of castles, in the most prominent position. The object of this custom was to enable the wayfaring stranger to remember and identify a certain house by the most conspicuous object in the heraldic device. Thus, if a rose, lily, lion, or leopard appeared in bold relief, the building was named by travellers little skilled in the mysteries of heraldry by one or other of these terms. After the overthrow of the feudal power and the suppression of the monasteries, the wayside hostelry was the only resource left for the wanderer, and it is not difficult to gather from the foregoing how the custom of naming public inns came into vogue. As the number of taverns increased, new signs were continually required; the heavens above, and the animal and vegetable kingdoms below, were called upon to furnish requisite subjects. The paucity of invention may be seen by recourse having been had to change of colour, such as the white, black, and golden swan; the black, red, and blue lion, &c. To assist the memory of those who could not read, the innkeeper, if the case admitted of a pictorial representation, frequently allowed his name to be idealised in paint. Thus, Jane Keye, in Bloomsbury Market, London, in 1653, kept for her sign a key; John Hive, of St. Mary's Hill, 1667, had for his sign a beehive; and the same year, at Queenhithe, Bartholomew Fish kept the sign of the "Three Fishes." Sometimes the landlords resorted to puns. Thus there is still preserved in Hatton Wall the

figure of a hat and tun, which is a pun upon the name of the host, Hatton. The "Brace Tavern," in Queen's Bench Prison, was so called from its being kept by two brothers of the name of Partridge.*

In the eighteenth century education was spreading fast, and reading was becoming a general acquirement. It appears, however, from No. 18 of the *Tatler*, that the first literary efforts of innkeepers on their signboards were far from satisfactory. The writer thus expresses himself:—"There is an offence I have a thousand times lamented, but fear I shall never see remedied, which is that, in a nation where learning is so frequent as in Great Britain, there should be so many gross errors as there are in the very direction of things wherein accuracy is necessary for the conduct of life. This is notoriously observed by all men of letters when they first come to town—at which time they are usually curious that way—in the inscriptions on signposts. I have cause to know this matter as well as anybody, for I have, when I went to Merchant Taylors' School, suffered stripes for spelling after the signs I observed in my way. Many a man has lost his way and his dinner by this general want of skill in orthography. I have a cousin now in town, who, going to see a relation in Barbican, wandered a whole day by the mistake of one letter; for it was written, 'This is the Beer,' instead of 'This is the Bear.' He was set right at last by inquiring for the house, of a fellow who could not read, and who knew the place mechanically only by being often drunk there!"

About the middle of the seventeenth century, rival tradesmen so outvied each other in the size of their signs, and so sought to push them into public notice, as to call forth an enactment in the reign of Charles II., wherein it was ordered "that in all the streets no signboard shall hang across, but that the sign shall be fixed against the balconies, or some convenient part of the side of the house." Here

* "The History of Signboards," &c., p. 474.

they have since remained. Subsequent legal enactments have removed from the public thoroughfares of London all the trade signposts and signirons. In the country, however, many of the innkeepers still retain the signpost with its swinging picture.

The facilities for travel given by improved means of communication, have induced thousands to visit strange towns and countries. Those who had previously never overstepped the limits of their fatherland may now be met with abroad. As a direct consequence, great hotels have been everywhere erected, which afford to travellers all the enjoyments and conveniences obtainable in their own houses.

CHAPTER II.

Arts relating to Building and Domestic Furniture.

SECTION I.—THE STONEMASON, BRICKMAKER, AND BUILDER.

The employment of bricks as materials for building in England was not revived till long after the Norman Conquest, but in the reign of Henry VIII., the art of brickmaking had attained to great perfection, and the remains of many mansions erected during the first century of the Tudor period exhibit some of the finest known specimens of ornamental brickwork. The use of terra-cotta for panelled friezes, cornices, bas-reliefs, and other ornamental work appears to have been common during the reign of Henry VIII. In Elizabethan times the use of brick seems to have been restricted to the larger mansions; whilst for common buildings timber framework, filled in with lath and plaster, was generally used, a construction which is in common use in tropical countries at the present day. Bricks were generally adopted in the rebuilding of London after the great fire of 1666. The number to be used in the thickness of the walls of the several classes of houses was then regulated by enactment.

Towards the close of the last century, bricks and tiles were subjected to taxation, but in 1833 the duties on tiles were repealed. In 1839 a uniform duty of 5s. 10d. per thousand was imposed on bricks, without distinction of shape or quality, in consequence of which moulded bricks, for cornices, plinths, string-courses, &c. were manufactured at a moderate price. Up to this time bricks were made by

hand, but the great extension of our railway system necessitated more expeditious and certain methods of manufacture; hence the introduction of machinery and other appliances.

Brickmaking machines were invented by Messrs. Cooke and Cunningham, who succeeded in moulding bricks at the rate of thirty a minute. Messrs. Clayton's machinery, introduced in 1861, turned out 1,500 an hour. The simplest machinery for the purpose is that for the compression of the earth or clay, whereby all mixing and drying are saved, and dense bricks or tiles come at once from the machine, ready for firing in the kiln. Minton's dry tiles, as distinguished from the encaustic ones, are formed by intense pressure, in the machine patented by Mr. Prosser. The superiority of machine-made bricks over those made by hand is indicated by their comparative resistance to compression, being in proportion of 13 to 11 in favour of the former.

The manufacture has not largely increased of late years, because, perhaps, of the more frequent employment of stone in the better class of buildings; but the extension of the use of tiles, drain-pipes, &c., has been very considerable.

The employment of hollow bricks, which gives an advantage over the use of ordinary bricks, in addition to a considerable diminution in the cost of carriage, is of recent date, though the idea of tubular bricks is not new, for they were used by the Romans in large vaultings, where lightness of construction was required; and they are said to be in common use in Tunis at the present time. These are also made by machinery, especially at the great clay-manufactory of Misbach, in Vienna. In this manufactory roofing, building, and ornamental tiles, water-pipes, and hollow bricks for arches are also made, and its works are among the most extensive in the world. It possesses 43 ovens, each capable of burning from 45,000 to 100,000 bricks. When all are in operation, 3,500,000 are

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being made at the same time, 4,800 hands being engaged upon the work. Messrs. Robert Brown and Co., of Paisley, have also introduced remarkable improvements in the application of fire-clay and glazed wares to architectural purposes.

The substitution of slates for tiles or thatch as a covering for houses is of modern date, and a strictly European innovation. Carew, in his "Survey of Cornwall" (1662), speaks of roofing-slates, and of their shipment to other parts of Britain and to the Netherlands. Since that time the use of this valuable material has been greatly extended; and the quarrying and production of slate slabs is at the present time a most important industry in several parts of the United Kingdom. Two slate-dressing machines contend for superiority. The results of a trial of the two was this—the "power" machine, in twenty-five minutes, finished 179 slates of various sizes, having a total superficies of 280 square feet; whilst the "sword-arm" machine completed in the same time 207 slates, with a surface area of 358 feet. Machinery is now also applied to sawing stone into slabs; dressing or planing its surface, as in slate billiard-tables, slabs for cisterns, &c.; polishing and carving, as in marble mantelpieces, tombs, and sculpture; and boring, for tubes.

The nature of the material used in building construction has generally been determined by the character of the district. The use of bricks is very limited in Scotland, because good building-stones abound in that country; whilst the scarcity of stone in Holland necessitates the extensive employment of brick. Singularly enough, the churches in the English fen-country are built of small stones, said to have been brought from a great distance on pack-horses. The extensive use of stone in the domestic architecture of Paris, Edinburgh, &c., arises from the proximity of these cities to quarries of that material. In London, till within the last twenty-five years, stone was the constructive material of our public edifices only, Portland limestone, ever

since the rebuilding of St. Paul's cathedral, having been chiefly employed; but now that the operations of quarrying stone and fitting it for economic purposes have been performed by special machinery, and that there are increased facilities for cheap carriage, stone is more generally adopted in buildings of a different class.

About forty years ago there arose, simultaneously with the development of railways, a new system of building arches, in which spiral curves are used as lines of construction. The art of building oblique or skew bridges appears to have been known on the Continent as early as 1530, but not to have been generally understood. Formerly bridges—which were built, with few exceptions, for carrying common roads over rivers and canals—were erected on a rectangular plan; and in cases where the direction of the road was not at right angles with the stream to be crossed, the approaches were altered so as to effect this. This arrangement was quite inadmissible in railway bridges; and, accordingly, with the first introduction of locomotives arose the necessity for constructing arches on oblique plans.

Since the end of the eighteenth century great improvements have been effected in the construction of lime-kilns. Those of Ludersdorf are thirty-six feet high, and supply the whole of Berlin with lime, at the rate of 300 cubic feet per twenty-four hours. In 1796, Parker, an Englishman, invented a mortar which hardens not only in the atmosphere, but also in water. A hydraulic mortar was subsequently prepared at a less expense from ordinary pieces of stone. This last is used for the submerged portions of the piers of bridges.

The plan of uniting iron and glass in building has been attempted with success. The Great Exhibition building, constructed in England in 1851, was made chiefly of these materials. Its ribs and supporting pillars were of iron, and its walls and roof of glass; the floor only was of wood.

SECTION II.—THE HOUSE-CARPENTER.

Towards the close of the Middle Ages stone and brick began, as we have seen, to be more used in building. This necessarily diminished to some extent the demand for carpenters' work. The loss, however, sustained by them was greatly compensated by the rapid growth of population and the number of houses erected to meet the requirements of the people. The old walls were pulled down, the moats filled up, and great cities became surrounded with extensive suburbs. Streets are made broader, and in place of tall, narrow houses, with steep roofs, dwellings, not so lofty, but with more frontage and a greater number of rooms, are now erected. In Bavaria and Prussia, 10,000 master builders and carpenters, besides 60,000 associates and workmen, are constantly employed. The master carpenters have acquired the mechanical and mathematical knowledge which is absolutely necessary to them. What the workmen of the Middle Ages knew only by experience is now learned and understood on sure and scientific grounds. Perfect accuracy in the construction of all kinds of mathematical instruments has been secured, and inquiries of the greatest importance as to the strength of materials employed in building have been satisfactorily instituted.

SECTION III.—THE JOINER AND CABINET-MAKER.

When a house is finished in respect of the architect, builder, stonemason, and carpenter, many details are still necessary to complete the minutiæ of the woodwork; and here the services of the joiner are necessary, for it is he who makes the doors, door-panels, window-frames, staircases, cupboards, and shutters. The cabinet-maker, in his turn, supplies the house with chairs, sofas, tables, bedsteads, wardrobes, and sideboards. Similar wants existed

thousands of years ago, and gave rise, as we have already seen, to these branches of industry.

Although during the last 300 years little progress has been made in the discovery of artistic designs, yet useful and beneficial inventions have by no means been wanting; and the materials for furniture have been largely increased through the discovery of new woods. The number of varieties of wood is now estimated at more than 200, some of these being of superior commercial value. Mahogany, discovered in Trinidad by Europeans in 1597, was first brought into use in England in 1724. In 1829, 19,325 tons of this material were imported, since which time the trade in furniture-woods has greatly increased, as well as that in timber for common purposes.

The art of veneering, once practised by the Greeks, was rediscovered by Filippo Brunelleschi. The first veneer-mill was set up by Renner, at Augsburg, in 1565. By the application of steam as a motive power, veneers are now rapidly cut, and worked to the greatest perfection. The arts of colouring, polishing, and lacquering have also been discovered. In the seventeenth century, a partially successful attempt was made to imitate the excellent varnishes of the Orientals, especially those of the Chinese, and in 1765 a manufactory was established by Stobwasser in Brunswick. Since then the art has been so much extended and improved in Germany that it equals the most considerable of the French and English manufactures of a like kind, whilst in taste, finish, and cheapness, it far excels them. Wood-gilding, too, has been carried to a high state of perfection. Besides these improvements, contrivances have been devised for facilitating the drying of woods. There are, in addition, cutting-machines, which give to the materials subjected to their action either level surfaces, mouldings, rabbets, or grooves. In 1851 an assortment of more than 200 varieties of planes was displayed at the Great Exhibition.

The introduction of so many kinds of wood, and the increased facilities for ornamentation, have largely developed the artistic modes of cabinet-making. Even in the sixteenth century splendid cupboards and dressing-tables were made, which still remain unsurpassed. The inlaid work of the period often represented landscapes, flowers, and historical events, and was not unfrequently decorated with precious stones, coloured glass, and mother-of-pearl, together with variegated emblems in gold and silver. The objects thus embellished were jewel-cases, writing-desks, and cupboards. There are still preserved in the museum at Dresden specimens of this elaborate work, as, for instance, the toilet-table of the Electress Anna. Such articles were even exported, for in 1554 Lorenz Strothmeier fitted a state chest for Charles V., and between 1562 and 1568 Bart. Weishaupt constructed a similar one for Philip II. The collection at the South Kensington Museum of articles of this nature should be visited and carefully examined with the aid of the official catalogue.

Internal decorations and articles of furniture are made of other materials besides wood. Paper-hangings have long ago displaced panelling. Attempts have been made to produce furniture from stone, papier-mâché, and mineral cement (*stein-pappe*). In the Exhibition of 1851 there was a magnificent pianoforte of this last material, as well as seats, card-tables, ladies' secretaries, toilet-tables, and chairs.

Growth of Towns, and Improved Means of Communication.

Closely connected with the art of building are two subjects which require brief mention, viz., the growth of towns, and the increase in the facilities for communication. Within the last three centuries many old baronial castles have disappeared or fallen into ruins, and the poor clay-built and straw-thatched hovels which surrounded them

have given place to structures of a more substantial construction. Ancient towns have undergone great metamorphoses. The houses, once built of wood, have given place to stone or brick dwellings; the streets have been widened, paved, and lit; and systematic drainage has been more or less completely effected. The walls, gates, and ramparts which once environed them have been removed or turned to other uses, and towns no longer confined within these restricted limits, have become surrounded by extensive well-built suburbs, gay with blooming gardens, the abode, for the most part, of the better class of the town population. The lighting of towns in its present completeness is an essentially modern feature, though there is historical evidence that Antioch and Edessa were wholly or partially lighted in the fourth century. Of modern cities, Paris, early in the sixteenth century, was the first to be systematically lit. London streets began to be lit towards the close of the seventeenth century. While much has been done towards cleansing and beautifying modern towns, much yet remains unaccomplished in the way of building convenient, well-drained, and well-ventilated houses in the poorer quarters of every large town.

A striking feature of modern improvements is the extension of the means of intercommunication, such as the great roads made by Napoleon, to facilitate the march of his armies. In 1805 he caused to be constructed over Mont Simplon a noble road, having 264 bridges, and numerous tunnels hollowed in the solid rock, and attaining at its highest point an elevation of 6,560 feet. The road over the Wurmser Mont, constructed by the Austrian Government in 1825, reaches the still greater height of 8,850 feet. Amongst the memorable engineering works of modern times, the Thames Tunnel, once used for ordinary traffic, but now a part of a railway, holds a high place. It has two arched ways, is 34 feet broad, and 1,140 feet long. The cost of its construction was £630,000.

Most noteworthy of all the modern means of communication are the railways, which have already spread their ramifications over every civilised country, although the system is but forty years old, for it originated with Stephenson, who constructed the Liverpool and Manchester Railway, opened in 1830. Railways are to be found everywhere, piercing through mountains, spanning great rivers and arms of the sea, and even ascending and descending mountains of considerable elevation. Of the tunnels bored for the passage of railways, the greatest is that now recently completed through the Alps, between France and Italy. Of bridges constructed by railway engineers, the following are among the chief:—Stephenson's Britannia Tubular Bridge, which carries the railway over the Menai Straits; Brunel's Royal Albert Bridge, over the Tamar, near Plymouth; the Victoria Bridge, over the St. Lawrence, at Montreal; and the Chain Bridge over the Dnieper, near Kiev. The Britannia Bridge is 1,841 feet long, 150 feet high, consumed 11,468 tons of iron in its construction, and cost £601,000.

SECTION IV.—AN OUTLINE OF THE HISTORY OF SHIPBUILDING.

The invention of ships is of great antiquity. The first boats probably sailed down the rivers Ganges, Tigris, Indus, Nile, and Euphrates. The Egyptians constructed vessels capable of navigating the Nile and its canals only, since they carried on no traffic by sea. The Phœnicians first made large and seaworthy ships, with which they traded both in the Southern Ocean and on the shores of Britain. The Greeks built ships both for war and commerce. The Persian fleet, at the battle of Salamis, consisted of 1,186 vessels; and Themistocles caused 20 ships to be constructed annually, to secure the naval supremacy of Athens over the rest of the Greek states, and to defend Hellas against Persian attacks. During the period of Rome's greatness, shipping from every known

country sailed up the Tiber. The Romans, in the second century before the Christian Era, had conquered their maritime rivals, the Carthaginians, and from that period they possessed two fleets, one stationed at Ravenna, and the other at Messina, which enabled them to maintain their supremacy in the Mediterranean. The ancient Phœnician, Grecian, and Roman vessels resembled huge boats, with a mast in their centre bearing the sails and standard, and propelled chiefly by the use of oars or paddles. On the larger ships there were battlements and towers, from which combustible materials and missiles were hurled.

After the destruction of the Roman Empire, the Normans were the sea-kings of Europe, and became in many places its masters, by the aid of their superior maritime force. Numerous transport and passenger vessels plied on the Danube and the Rhine during the eleventh and twelfth centuries, and kept up an active commerce with Constantinople. At the period of the Crusades, in the twelfth and thirteenth centuries, the Hanseatic League had developed its maritime power in the North of Europe, whilst in the South the Italian cities, Venice, Pisa, and Genoa, had an extensive maritime commerce, which rendered the Mediterranean, as in the flourishing days of Greece and Rome, the commercial rendezvous of the African, Asiatic, and European nations. When the compass came into use, the chief theatre of navigation was transferred from the Mediterranean to the Atlantic. It now became possible for vessels to venture boldly out to sea. The result was the geographical discoveries of the fifteenth and sixteenth centuries, alluded to in page 207, and made principally by Holland, Spain, Portugal, and England.

To facilitate these enterprises, great improvements were made in the building both of ships of war and those intended for the more peaceful pursuits of commerce. The vessels of the Middle Ages were of the size of modern boats. Those subsequently built by Spain were huge and clumsy,

towering above the waves with their several decks; those constructed in Arabia and Italy could only make progress with a full wind behind them. The ships, however, trading from English ports, although smaller, were much more manageable, inasmuch as a plan was discovered whereby every breeze could be made available, by a suitable adjustment of the sails. After the seventeenth century, vessels were built in the greatest variety of forms, from the light one-masted sloop to the man-of-war carrying from 40 to 120 guns, manned by upwards of a thousand men.

In the beginning of the present century, steam being applied to navigation, ships were rendered capable of making headway against both wind and tide. On the 3rd of October, 1807, the first steam-ship was launched, near New York, by Fulton. In 1826 the Cape of Good Hope was doubled by steam; and in 1838 the first of a system of regular voyages across the Atlantic was effected by its means—the *Great Western* left Bristol, where she was built, and in fifteen days entered New York harbour, though as early as 1819 the Atlantic had been twice crossed by a small steam-vessel, the *Savannah*. In 1852 the *Australian*, an iron steam-ship, left Plymouth, and after a voyage of seventy-six days anchored safely in King George's Sound, Western Australia. The *Great Eastern*, built in 1859, by Mr. John Scott Russell, from designs by himself and Mr. Brunel, is the greatest triumph of naval architecture in modern times. This magnificent ship is 691 feet long, 83 feet broad, and 58 feet in depth. Its tonnage is registered at 18,914 tons, although it is said to be capable of carrying 25,000 tons.

Similar progress has been made in the construction of vessels of war. Ships are now coated with iron plates, and carry fewer guns, but are, nevertheless, capable of throwing a much heavier weight of metal. Ironclad ships were much used in America during the late civil war; and England and the other maritime nations of Europe have, since that

time, largely replaced their wooden fleets by vessels of a like kind.

Since the completion of the Suez Canal, iron shipbuilding has received fresh impetus. Our facilities for the construction of cheap iron vessels promise us a great advantage in the competition for the carrying trade of the ocean.

SECTION V.—THE TURNER AND TOY-MANUFACTURER.

History does not inform us whence the knowledge of the art of turning was derived. For centuries the lathe was unknown, and it has only very gradually advanced to its present improved form. The skilled operative now produces by the turning-lathe, not only rounded work in wood and metal, but the most exquisite figure-forms and complicated geometrical designs. Turners are mentioned as among the artificers of Charlemagne's farms, and are called "*formatores.*" After this period, carving in ivory and wood became more generally practised for ecclesiastical objects, such as altars, pulpits, sacristies, organ-cases, and fonts. From religious edifices the art found its way into private dwelling-houses. Although there is no evidence to show it, yet it is conjectured that the turning-lathe was employed towards the close of the fourteenth century. A letter of Martin Luther's is extant, in which a request is made for turners' tools of Nürnberg manufacture. He extols their delicate and beautiful workmanship, in comparison with the clumsy production of his own hands.

Turners in bone had established themselves in Geistlingen in the fifteenth century, and the appellation "goblet-maker" seems to have been used to designate those who turned drinking-vessels of horn, wood, and bone. Turners' work received a new impulse at the close of the Middle Ages. The desire for ornamentation became stronger in all grades of society, and many novel wants arose, which the

art of the lathe alone could supply. Spinning-wheels, tobacco-pipes, buttons for clothing, chessmen, nine-pins, and billiard-balls, were some of the products of the labours of turners. The great demand for such goods split up the craft into several distinct branches. Metal as well as wood turning became common. In the middle of the sixteenth century, the brass and copper smith's turning-machine was invented.

Many improvements were now introduced. Ridley, an Englishman, rendered unnecessary the heavy treading of the wheel, by so directing the power brought to bear on the treadle that the least pressure of the foot ensured the rotatory movement. Hitherto, in turning a piece of work at the lathe, the material, whether of wood, horn, or ivory, had been made to revolve, and the workman, whilst holding the cutting-tool firmly, and pressing its point against the material, reduced its surface to the required shape and size. It is obvious, however, that great care was required in the operation, and that the work would sustain much injury if the pressure were unequally applied. To remove these sources of imperfection, Henry Maudslay, an English mechanician, invented the slide-rest, which is now attached to all but the most ordinary lathes. In this apparatus, the rest, instead of being screwed down to one place, itself holds the cutting-tool whilst it advances slowly along the bed with the revolution of the material to be turned. For the beauty and accuracy of the present system of turning amateurs are much indebted to the late Mr. Holzapfel.

"The steam-engine itself," says Mr. Nasmyth, "owes its perfection to this admirable means of giving to metallic objects the most precise and perfect geometrical forms. How could we have good steam-engines if we had no means either of boring out a true cylinder, or turning a true piston-rod, or planing a valve-face?" Various modifications of instruments acting on the slide-rest principle were next produced, such as the planing and wheel-cutting machine,

the latter of which forms the teeth in the watch and clock maker's wheels, and is one of the most valuable applications of the lathe. Besides ordinary circular turning, every variety of movement is now given by means of alterations in the chucks used to connect the material with the lathe. Patterns are thus produced on plates and blocks for printing and embossing, and ornamental work is turned out in a manner impossible before these appliances were invented. All these systems, however, have been surpassed since the machinery of the turner has been impelled by steam. Metal can now be cut into any form that may be required for engineering purposes, with a facility such as could previously only have been brought to bear on the most supple wood. In 1846 a machine was invented by Leicester, which prepares in the course of a minute twenty-four small wooden reels for sewing-thread, from one to one and a half inches in length.

In the last century an innumerable variety of objects were turned in horn, bone, ivory, mother-of-pearl, tortoise-shell, alabaster, and metals, and exported from Nürnberg to almost every country in the world.

The toy manufacture has since largely spread from Nürnberg to the Tyrol, Switzerland, Bavaria, Wurtemburg, Hesse, Franconia, and Saxony. The Hanse Towns export annually to England nearly 350,000 cwt. of such goods. In Paris there are 400 toy manufactories, employing more than 2,000 workmen, and producing goods to the value of 5,000,000 francs annually. Walking-sticks are extensively manufactured in England, and magazines of every kind of wood are collected from all parts of the world and stored up for this purpose. London alone sells 500,000 sticks annually. Similar establishments exist in Hamburg, Vienna, Berlin, and Paris. In the last city there are 651 cane manufactories, the productions of which are valued at £120,000 annually.

SECTION VI.—THE COOPER

In the sixteenth century cooperage was carried to the highest state of perfection in Germany. This prosperity manifested itself in the construction of enormous vessels. Although no such monstrous vats are now built in the workshops of the cooper, the business has, nevertheless, increased in proportion to the extension of the wine, spirit, and malt trades. In London the leading brewers have immense receptacles, which are far superior in size to the old tuns of Heidelberg and Tübingen. In Bohemia and Bavaria 12,000,000 *eimer* or buckets of beer are annually produced, for which large cellars and barrels are needed.

Coopers' vessels are now much more conveniently made than formerly, being hooped with iron instead of wood. Numerous patents have been taken out for making casks by machinery, but none of the processes have yet come into general use.

SECTION VII.—THE ROPEMAKER.

A rope consists of the fibres of hemp, or some other material, so intertwined as to form a strong flexible cord. These fibres are first twisted into thick threads, usually called rope-yarns. From fifteen to twenty-five of these are said to form a strand, three strands a rope, three or more ropes a cable. These, however, are only the leading varieties, for commerce requires cordage of every kind, from twine, string, or cord, to the powerful rope of a ship at anchor. The principle of manufacture is nevertheless the same. We possess the most complete information concerning the improvements in ropemaking since the close of the Middle Ages. First there is the hemp-refining machine of Christian, of Paris, which provides a quicker and better mode of rotting the soft tissue, and of separating it from the fibre; then we have stamping-mills for bruising the hemp, as a substitute for the

hand labour formerly employed on this part of the process; lastly, the better combs made by Otho of Gotha, Legrad of Vienna, Porthouse, an Englishman, and Fourier, a Frenchman, although not brought into general use, have attracted much attention. The attempts to manufacture cordage from the fibre of the China nettle and the cocoa-nut, from Manilla hemp, and from New Zealand flax have been completely successful. Indeed, this last plant is now of great importance, as yielding a more durable and cheaper tow. Although made known by Cook's first voyage, it was not introduced into England till 1831. At the present time many thousand cwts. of it are annually consumed.

The tension of cordage or the strength of different varieties of rope has been made the subject of scientific experiment by Réaumur, De la Hire, Throneder, Duhamel, and others. It has been discovered that a very considerable amount of strength is lost in the twist, and that ropes the least twisted will support the heaviest weights. Mögling, in Wurtemburg, by means of a peculiar weaving-machine, has succeeded in making fire-engine pipes of hempen web. Flat ropes were patented by Chapman, of Newcastle, in 1807. They are extremely flexible, on account of their thinness, easily made into coils, and particularly serviceable in mines. They sustain, it appears, a much greater weight than round or cylindrical ropes.

Rope machinery, to the invention of which Cartwright, Fothergill, Curr, Huddart, and others have contributed, now forms cordage of all kinds with very little trouble. Huddart's machine is especially valuable, securing as it does the most perfect regularity in the formation of the yarn. By its means a rope can be made of any length, whilst in portability, strength, and beauty, its productions are superior to every other. The fibres are so twisted that in every strain each thread is equally stretched. Every branch of the rope-manufacture can now be carried on by the aid of machinery.

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In 1833 wire ropes were first made at Klausthal, by Obergrath, and are now much used in mines. They are not so flexible as those of hemp, but are thinner, lighter, less bulky, not affected by moisture or dryness, more durable, and cheaper. They are prepared by machinery, and used on shipboard with considerable advantages over hempen cords. In the largest ships there are often from 50,000 to 100,000 feet of wire rope.

SECTION VIII.—THE POTTER.

The first advance in the art of pottery took place in Italy, at the commencement of the sixteenth century, where the excellent native clay was worked up into Majolica ware at Faenza, Pisa, Urbino, and Gabbio. Some of this ware was greatly enhanced in value by the addition of paintings by Raphael, Titian, and Michael Angelo. This ware was most extensively manufactured from 1540 to 1560. It was especially patronised by the dukes of Urbino, but Duke Francesco II. dismissed his artists, and the ruin of the manufacture followed. It was, however, introduced into France, where exceedingly handsome goblets were made of fine, white, hard clay, and adorned with beautiful enamelling. To recommend these goods the French potters named them "Fayence," and at the beginning of the eighteenth century they exceeded all other in their material truth of delineation and beauty of colouring.

About this time the works of Palissy, the French potter (born 1509) became famous. He executed in relief reptiles, fishes, plants, and even fossil shells, with the most marked attention to the minutest details.

The use of the early English ware was continued until the commencement of the eighteenth century, when artists began to recognise the fineness of English clay, and to make use of ground flint. The manufacture of earthenware was so much improved in 1759, by Wedgwood, that to him the

honour of its re-invention has been attributed. At first he produced a pale cream-coloured stone, named by him "queen's ware," but he afterwards imparted to it the richest colourings. Previously to this, in 1690, the brothers Elers had come from Nürnberg, and established works at Burslem, where they made imitations of Japanese pottery. They were, however, compelled to abandon their manufactories in Staffordshire about 1710. Every precaution was used by the brothers to keep their business secret; and it is probable that this circumstance, joined to their success, excited so much enmity that they were obliged to leave the country. Persecution subsided when their successor, a man named Astbury, commenced the business. He had, it is said, become master of their secrets by a singular stratagem. Feigning to be of weak intellect, and looking as silly as he could, he obtained employment in the Bradwell Works, and submitted to all the drudgery and contempt which were drawn upon him by his supposed weakness. By this course he was enabled to learn all that was done in the manufactory, and to make models for his own use of all the utensils.

To Astbury is often ascribed the introduction of white stoneware, by the adoption of calcined or burnt flints. The common story is that while travelling to London on horseback, in the year 1720, he had occasion, at Dunstable, to seek a remedy for a disorder in his horse's eyes, when the ostler at the inn, by burning a flint, reduced it to a fine powder, which he blew into them. The potter, observing the beautiful white colour of the flint after it was burned, instantly thought of the use to which it might be applied in his own art.

Pottery was brought to still greater perfection through the discovery of kāolin, and its manufacture into porcelain. This clay is found in some parts of England, but abounds and has been used in China for several thousand years. It was first brought to Europe by the Portuguese in 1513,

and was called "*porcelana.*" The earliest mention of China ware in England is in 1580. The great beauty and superiority of porcelain ware soon caused it to spread rapidly throughout the whole of Europe. Böttger was induced to examine *Schnorrische weisse Erde* (Schnorr's white earth), which was then used as a substitute for wheaten flour in hair powder, and this led to the discovery of the use of kāolin in porcelain. His first production was a brown mass resembling jasper, but in 1709 he made white porcelain. In 1710 the first manufactory was established by Augustus II., Elector of Saxony, in the castle of Albrechtsburg, near Meissen, and Böttger was appointed director. The establishment was a complete fortress for the confinement of the people employed, and "Be secret until death" was inscribed on the walls of the workshops; but the mode of the manufacture became known, and a large trade arose at Vienna in 1720, Berlin in 1751, at Nymphenburg, near Munich, in 1755, and at Sèvres, near Paris, in 1769.

The revival of the manufacture of terra-cotta in England is due to Wedgwood, who, in 1770, established large works in Staffordshire. His works were in imitation of the ancient vases and *pateræ.* In 1790, a manufacture of decorative works in biscuit-ware was carried on at Lambeth by Coade. The chief materials employed were Dorset and Devon clays, with fine sand, flint, and potsherd; and the articles manufactured were statues, vases, and architectural decorations, such as capitals, plinths, friezes, &c.

The Eastern nations were from the earliest times famous for their works in pottery, and the Chinese and Hindoo biscuit-wares are similar to terra-cotta; but embellishment in that material again declined, because of the great patronage given during the first fifty years of this century to the use of cements for all kinds of architecture; and it was not till the Great Exhibition of 1851 that public attention was again called to the value of baked clay articles for architectural and garden decorations. In Belgium and Holland

porous biscuit-ware vessels and vases are common, but the largest and most magnificent works in terra-cotta of a sculptured class have been made at Toulouse and Sèvres.

Various arts have united in lending their aid to the once vulgar and lowly craft of pottery, and we have to chronicle advances in the construction of the potter's wheel, the rolling-press, and in the manner of baking, glazing, and colouring. Machinery is now introduced into every stage of the earthenware or pottery industry, from the sifting of the materials and mixing of the paste, to the moulding on the lathe and the printing in colours. Since the Middle Ages the following varieties have appeared:—Pure porcelain, statuary and biscuit porcelain, coarse and fine stoneware, glazed and unglazed Fayence ware, and ordinary earthenware goods. In the Great Exhibition of 1851 various specimens, of admirable design and execution, showing the different stages in the manufacture of pottery, were shown, and were much appreciated by the public generally. Soft and hard masses, once or twice baked, glazed, enamelled, and painted, moulded on the wheel, pressed, or finished on the lathe; all were represented.

The importance of the potter's art, as at present existing in Great Britain and Ireland, may be inferred from the following facts:—The exports are valued at £1,500,000 sterling, and the home consumption absorbs £1,000,000 worth more. For this total 800,000 tons of coal are annually consumed, and 350,000 tons of clay, flint, spar, bone, and stone are used. The gilding consumes £60,000 worth of gold; and 80,000 men, women, and children find employment in this branch of industry.

English earthenware exceeds that of France and Germany in fineness, purity of material, and durability of glazing. One pottery—that of Minton and Co., at Stoke-upon-Trent—consists of three large buildings, and gives employment to 1,000 workmen. At the present time there are upwards of 200 earthenware manufactories in England. In Lam-

beth the greatest variety of stoneware goods is made, such as drain-pipes, condensers, worms, funnels, pans, baths, crucibles, and other chemical apparatus, filters for domestic use, druggists' pots, and tobacco jars. Recently, in one important class of goods, including white and coloured tiles, and insulators for telegraphic purposes, machinery has taken the place of manual labour. In the same district there are now seventy kilns, with an average capacity of £50 worth of ware per kiln. One firm alone, that of Messrs. Doulton, work annually about 8,000 tons of clay, which require a similar weight of coal to bake. Very successful attempts to imitate the Majolica ware have also been made, and the demand for statuary or Parian and biscuit porcelain is steadily increasing. Celebrated works of art, such as the "Ariadne" of Danneker, have been successfully copied. France, however, takes the lead in the porcelain manufacture. The French have sixty factories, the chief of which is that belonging to the Government, at Sèvres. This establishment produces the greatest variety of forms and of original designs, availing itself of the best models, the Greek, Etruscan, and Roman being chiefly followed. It also profits by the delicate Oriental models of India, Persia, and Japan.

SECTION IX.—THE GLAZIER.

Glass is an artificial product, formed by the chemical union of silica with an alkali, such as soda or potash, and the addition of certain supplementary materials, usually known as metallic oxides. These are added sometimes to produce colour, as the oxides of iron and of manganese, or to render the colour soft and more easily workable, as red oxide of lead. When the mixture is heated, it fuses into a viscid mass, called technically the "metal," which when cold is the glass of commerce. Glass is one of the most beautiful and useful of the many products of art. When cold it is a

solid, transparent, hard, brittle substance; but when heated it is so ductile, tenacious and flexible as to admit of being spun into the finest threads or moulded into any conceivable variety of form. These properties render it very serviceable, especially for windows. The mediæval use of glass, and the primitive contrivances for screening windows have already been referred to.

Glass-houses, for the manufacture of glass, appeared in Germany at the commencement of the sixteenth century; one was established in England in 1557, in Sweden in 1641, and in Portugal between 1702 and 1750. Even in the beginning of the eighteenth century, oiled paper was commonly used in the wooden window-frames of the French peasantry, the carpenters having the exclusive right of inserting them; and as late as 1751, there were still many paper windows in Marlie, Turin, Milan, Florence, and other Italian cities. The glass-makers of Murano, near Venice, were esteemed as noblemen. From the beginning of the seventeenth century, glass manufactories increased throughout Bohemia, where, at the close of the eighteenth century, there were seventy, employing 5,000 persons, and producing articles valued annually at about £200,000. Numerous and important improvements were also made. In melting, the material was rendered colourless, more transparent, and cheaper. Bottles, a great rarity in the fifteenth century, are now produced in abundance, in every variety of form. About 60,000 are made weekly in the manufactory of Edgar Bressart, at Castleford, near Pontefract, and 3,000,000 annually in that of the Brothers Bricolaine, at Paurrot. Drs. Fuss and Pohl, in England, have been successful in imitating the artistic Venetian glasses, with their white, delicately-veined threads, and regularly-formed straight and winding lines. Venice was for a long period celebrated for its glass; and, besides the ordinary manufactures, it furnished the *vitro di trino*, a fine lace-work, forming a series of diamond-shaped figures, the centre of

each having an air-bubble; frosted glass, the art of making which was temporarily lost till it was revived in England in 1850; filigree glass, which consisted of spirally-twisted white and coloured enamel glasses, cased in transparent glass; millefiore glass, mosaic glass, &c. The art of making glass beads was rediscovered at Murano, where the trade is still great, and where they make them of 200 different shades of colour. In Bohemia large quantities of beads are made, the annual export exceeding 5,500 cwt.

Glass is now drawn out into the finest and most flexible silk-like threads, and woven. A piece placed on a wheel three feet in diameter, and making 500 revolutions per minute, has been extended to a length of 90,000 feet. Factories exist in Paris, Milan, Venice, and Bremen, in which church ornaments and tapestry are prepared from glass. The lustre of such articles is imperishable, and far exceeds that of the most costly silken fabrics. Increased dexterity in blowing has brought window-glass to extraordinary perfection. The earliest windows had a decidedly greenish hue. The panes were very small, were encompassed with stout edges, and had a large bulging in the centre. The modern art of blowing, discovered in Bohemia and France during the course of the last century, at first was practised in the form of a balloon and then of a pear. From the latter cylindrical glass is obtained, from the former Mondglas. The cylinder thus procured is cut with a diamond on the interior surface, and exposed to the heat, which widens the incision. Whilst thus softened, it is spread into a flat sheet, from which squares are cut, stronger, much larger, and more uniform in thickness. Plate-glass is now made in enormous quantities; Chance and Co., of Birmingham, prepare 21,000 cwt. monthly, in twenty meltings, and send forth annually 21,000,000 square feet. They have exhibited plate-glass six to eight inches in thickness.

The old glaziers experienced considerable difficulty in cutting. They generally used emery, sharp-pointed instru-

ments of the hardest steel, or a file, with which a cut was made, and then with a red-hot iron the incision was directed according to pleasure. In the sixteenth century the art of using the diamond was discovered by Louis de Bequem, of Brussels, and towards its close improved window-frames, called the "glazier's vice," were substituted for the old unsightly ones of lead. Since the casting of plate-glass has been adopted, much larger windows and mirrors have been constructed, enormous panes being common in the shops of London, Paris, and New York. The windows of private houses may now be seen with single sheets upwards of ten feet in height, and seventy inches in width. The process of blowing, however, still continues. Crystal and flint glass are now produced far superior in colour, transparency, and lustre to the common plate and window glass. Crystal glass is used for ornamental objects such as sconces, chandeliers, cups, and chalices.

The art of engraving on glass, discovered by Caspar Lehmann, in the beginning of the sixteenth century, and that of etching, first practised in 1670, by Schwanhard, at Nürnberg, have been gradually improving up to the present time.

Flint glass is an English invention, made by Ravenscroft in 1700. It is used chiefly for optical instruments, on account of its purity and perfect transparency. The extraordinary refracting power which can be given to it has made it one of the most valuable accessories to scientific discovery. A telescopic lens, fourteen English inches in diameter, was shown at the Paris Exhibition in 1855. This was generally admitted to be the finest optical specimen then produced. It was purchased by the French Government for £1,000, and is now fitted into the principal telescope in the Observatory at Paris. Flint glass was greatly improved by Frauenhofer, who produced it in sheets.

Milk-glass is produced by mixing white glass in a fluid form with a substance insoluble in glass. It is principally

used for lamp-glasses. The Salische Government house, belonging to Count Baruth, is celebrated for the manufacture of such lamp-glasses, supplying annually 350,000 so pure that English glass-makers are unable to imitate them.

Every kind of colour is now obtainable on glass, and the mediæval art of painting on it has been revived. After the sixteenth century this art fell so much into disuse that by 1768 nearly all the workshops were closed, only one being found in Paris. It was resuscitated in Bavaria in the beginning of the present century, through the energy of Michael Sigismund Frank, born at Nürnberg, in 1778. The trade has developed into a more prosperous and advanced state than ever. With the mosaic-work real painting is combined, and vitrescible colours, of which metallic oxides form the base, are now laid on the glass, and burned into it. Glass-painters are established at the present time in Paris, Brussels, Munich, and Nürnberg, and, as manufacturers and workmen, are not only equal to the best of those of earlier times, but in many respects superior.

The countries now most distinguished for glass-works are Germany, Belgium, Austria, France, and England. Venice, formerly so renowned, has long been surpassed by other countries. Austria makes annually 400,000 cwt. of glass, worth £1,500,000 sterling. Prussia and Bavaria, taken together, have 130 houses, with 300 ovens, and about 100 glass-cutting and polishing establishments, employing 7,000 masters and 3,000 workmen and apprentices. In Belgium the goods annually produced are worth about £500,000, whilst nearly 50,000,000 square feet of glass are furnished to the manufacturers. England has taken a prominent position, this branch of industry furnishing annually 36,000,000 square feet of glass, worth in all about £700,000.

Pastes, Factitious or Artificial Gems.—The vitreous body called "strass," from the name of its German inventor, is a glass possessing purity and transparency in the highest degree, combined with the greatest possible lustre. It is

prepared from rock-crystal, boracic acid, and caustic potash, purified by alcohol—sometimes red lead and at other times white lead being employed. This glass constitutes the base of artificial gems, the colours of the precious stones being imitated by combining the perfectly pure and colourless strass with metallic oxides. Thus, the Oriental ruby is prepared by adding purple of cassius to the base; the Oriental topaz, by oxide of antimony; the emerald, by oxide of copper, or chromium; the sapphire, by oxide of cobalt; the amethyst, by cobalt and gold; the beryl, by antimony and oxide of cobalt; the opal, by bone-ashes, oxide of uranium, and forge scales, or in some cases oxide of nickel, &c. The uncoloured diamond may be well imitated by the strass alone. The French are supposed to excel in this branch of industry. Gablong, in Bohemia, is the chief seat of the manufacture of glass pearls and fluxes, where they are produced annually to the amount of £90,000.

Artificial Pearls.—The practice of making hollow glass beads and filling them with a pearly varnish was adopted at an early period by some artists at Murano, but was prohibited by the Venetian Government. This ingenious art, however, was revived and improved by Jacquin, a French bead-maker, who employed the brilliant silver scales of a small river fish, the bleak, called in France "*ablette*" (*Cyprinus alburnus*), to imitate the pearly lustre. At first beads made of plaster of Paris were covered with the material, but the wearers found that the powder left the bead and adhered to the skin. They were then composed of a bluish, opalescent, very thin glass, containing but little potash and oxide of lead; and the pearl essence was blown in warm, and spread over the internal surface by rapid motion. When dry, the globules were filled with wax, bored through with a needle, strung on threads, and mounted into necklaces, after the manner of real pearl ornaments. These beads are now made of all shapes and sizes, the most perfect imitations being sold at high prices. Their manu-

facture is almost solely confined to Paris. Artificial pearls have been made to resemble genuine articles so closely that experts have not been able, without the use of the file, to discern the true from the false. A story is even told of a dealer placing by accident a valuable necklace with one of spurious pearls, and then fearing to use the test, because of the damage that might be produced to the real pearls.

Glass, as we have before observed, has of late been much used instead of stone, metals, and other materials, for architectural purposes, as in the case of the Exhibition building of 1851 at Kensington, the Crystal Palace at Sydenham, and portions of our large metropolitan railway-stations.

The annual value of the glass-ware of Europe is estimated at £6,750,000.

SECTION X.—THE SOAP-BOILER AND TALLOW-CHANDLER.

Since the Middle Ages the quantity of soap manufactured has greatly increased, and improvements have been made in its composition. The preparation of new and valuable oils, such as palm, cocoa-nut, and sesame, besides the cheaper seed-oils, as linseed, rape, poppy, and even cotton, has been perfected. Through the labours of Black, Berzelius, Meyer, and Dossil, potash has been prepared in a purer state, and from a greater number of substances. Hungary, at the present time, supplies 200,000 cwt. of potash, and France nearly 100,000,000 kilogrammes of soda.* The scientific manufacture of soap was begun by Chevreul, between 1813 and 1823. He discovered the chemical nature of oily substances, and the influence of alkalies on their decomposing products.

The different kinds of soap have been classified, according to the alkalies which they contain, into soda and

* "Manufacture of Soap," see Jury Report for 1851, pp. 605, 606.

potash soaps, tallow and oil soaps. The use of oil-soaps predominates in the South of Europe, that of tallow in the North. The former is manufactured at Marseilles on a large scale. The manufacture has been brought to a high state of perfection, French toilet soaps being distinguished for their tasteful forms, fine colours, and excellent perfumes. To these belong the almond, scum, and beautifully-transparent Windsor.

Long after the Middle Ages, candle-making remained in a very imperfect condition. By degrees, however, improvements were effected, and in the seventeenth century the method of making candles in moulds of tin, iron, or glass was adopted. The present number of chandlers in England is estimated at about 3,000, whilst the total importation of tallow from Russia, Australia, South America, and other countries is said to reach 160,000,000 lbs., Petersburg alone forwarding 700,000 lbs. per annum.

Candles, however named, are chiefly made of spermaceti or of paraffine. The former is a solid substance found in the head of the sperm whale; the latter is procured by exposing a particular kind of coal to a red heat in iron retorts, and then refining by repeated distillations. Pure paraffine is not in the least dangerous; and it is only owing to the spirit left in the oil, through careless preparation, that so many accidents have occurred. The solid substance from which the candles are made is simply a condensed coal-gas; in fact, a paraffine candle, when burning, has been said to be really a gas-house on a small scale.

When candles came into general use the lamps of the Middle Ages were laid aside; but European civilisation, in its progress, again returned to its former habit, and in the eighteenth century we find the streets of the principal cities in Europe lighted with oil. "About this time, in London, a Swiss, named Argand, invented hollow, cylindrical, reed-like wicks, which burned clearly without smoke, and were at the same time self-snuffing. To understand fully the nature

of his improvement, it must be remembered that a plentiful supply of air is necessary to the existence of flame. A small wick produces, of course, a small flame; but, in consequence of that smallness, almost every particle of the flame is in contact with the air, and the light is very brilliant. By increasing the size of the wick the flame is enlarged, but then the interior portion, which is deprived of air, is but imperfectly inflamed; the light is, in consequence, brown and dull, and much of the oil burned passes off in smoke without being inflamed at all. The only mode found of increasing the body of flame without destroying its brilliancy was by increasing the number of little wicks, which were placed side by side in a line. This produced a good light, but it was unsightly and troublesome to arrange, and by no means so brilliant as might be expected from the same quantity of light in a compact form. It occurred, therefore, to Argand that if this line of wicks could be placed in a circle, and a current of air admitted through the interior of the circle, while the outside air was applied to the external surface, the power of a large wick would be obtained with all the brilliancy of a small one. This was effected in the following manner:—A small tube, about three inches long and half an inch in diameter, was soldered at one end, withinside another tube of the same length, but double the size, leaving a space between the two, open at one end and closed at the other. A wick was formed by a piece of cotton woven round without a seam, and fixed to a brass ring fitted to the space between the two tubes, and raised or depressed by a worm or groove cut in the inner tube, or by a rack and pinion. The oil was admitted to the wick by a pipe connected with a reservoir, and passing through the outer tube. Thus was formed a ring of light; but the lamp did not at first answer the expectation of the inventor; the light was not brilliant in proportion to its size, and could not be got to rise much above the wick. Every attempt to increase its height, by a more copious flow of oil,

or by raising the wick, only produced a volume of smoke. The defect would have been fatal had not accident discovered a remedy. This was the glass chimney, which, by increasing the current of air, produced a complete combustion of oil, and as great a light as could possibly be derived from the quantity consumed. The accidental discovery is thus related by the younger brother of Argand:—'My brother had long been trying to bring his lamp to bear. A broken-off neck of a flask lying upon the chimneypiece, I happened to reach it over to the table, and to place it over the circular flame of the lamp; immediately it rose with brilliancy. My brother started from his seat with ecstasy, rushed upon me in a transport of joy, and embraced me with rapture.' Thus was the Argand lamp formed; the most important improvement discovered in artificial light before the introduction of gas, and on which no improvement has since heen made. More convenient arrangements have been made to supply oil, more elegant forms have been adopted, and all unnecessary shadows obviated, but the burner remains essentially the same as Argand formed it."*

Towards the close of the eighteenth century, camphine and coal-gas were discovered, both of which yield brighter flames than common lamp-oil. The dismal light which formerly glimmered in the streets has given place to gas, the introduction of which into private dwellings has to a great extent superseded the use of the lamp and the candle.

Without going into further details on illumination, or attempting to describe the properties of magnesium, we may add that the electric light, discovered by Sir Humphry Davy, and inferior in brilliancy only to the sun, has already been applied to the illumination of lighthouses, as, for instance, that at South Foreland, near Dover. This illuminated warning is visible at the distance of above twenty-seven miles, and can be seen from the lanterns of the lighthouses on the coast of France.

* "Seven Ages of England."

CHAPTER III.

ARTS RELATING TO CLOTHING.

SECTION I.—MODERN TEXTILE INDUSTRY.

UNDER the Tudor dynasty, weaving, which had long been in a declining condition, once more began to flourish in England. The Spanish persecutions in the Low Countries drove hither many skilful operatives. The revocation of the Edict of Nantes, at a later period, caused nearly a million of the most peaceable and industrious citizens of France to seek shelter in Switzerland, Germany, the Netherlands, and England. An ignorant jealousy of foreigners caused the exiles to be received here with less welcome than they met with in Holland; 50,000 of them, nevertheless, made England their home, and founded industries which have been long of national importance. The subsequent prosperity of Holland is traceable in a great measure to the manufactures encouraged by the hospitable reception given to these Protestant refugees.

A restless meddling characterised British legislation, which, under the belief that it promoted the progress of the textile arts, really interfered with it. Manufactures were confined to specified localities, the number of dyes to be used was regulated, foreign interchange was controlled, monopolies were granted, sumptuary laws were imposed, and grave-clothes of wool were made compulsory. Indeed, this last restraint was not repealed till the beginning of the present century. Woollen-weaving was discouraged in Ireland, with the idea that it injured English industry. Owing to like ill-judged interferences, the linen trade was prevented

from flourishing in England, and restricted for the most part to Scotland and the North of Ireland.

With the general improvement of agriculture in modern times, increasing quantities of flax were cultivated, and cotton and silk stuffs were added to the products of the Northern looms. Previously these fabrics had been imported from Italy and Greece, and the cost was in consequence too great to render their use common. As domestic manufactures, their supply became abundant and cheap, and within the reach of the industrial classes. The manufacture of silk was introduced from Italy into France by Francis II. About 1685 a large number of French silk-weavers resorted to Spitalfields, and contributed much to the progress of the manufacture. A further and special improvement is traced to the family of the Lombes, originally of Norwich, but afterwards of London. The Italian silk manufacturers had, by the aid of their improved machinery, become so superior to the English that the latter found competition of little use. In 1715 the youngest of the brothers Lombe proceeded to Leghorn, nominally to acquaint himself thoroughly with trade, but really to obtain such an acquaintance with the Italian machinery as might enable him to introduce it at home. The Italians had enacted severe laws to guard against betrayal of their secret, but these did not deter the adventurer. On his arrival at Leghorn he obtained permission to view the silk-works. This availed him little. He was hurried through the rooms, and given no time to examine the whirling and complicated machinery. Under various disguises, he revisited the mills, but with the same result. Eventually he managed to ingratiate himself with the priest who confessed the family of the proprietors, and by his recommendation obtained, in the character of a friendless lad, employment in the mills. His mean appearance disarmed suspicion, and he was accommodated in the buildings containing the object of his search. Secreting his lantern, tinder, wax-candles, and mathematical instruments

during the day in a hole beneath the stairs which served as his place of rest, he spent the night in making drawings. These were, by the aid of the priest, conveyed to an agents', Glover and Unwin, by whom models were made from them and shipped piecemeal to England in bales of silk. These models are still, it is believed, preserved in the Derby Mills. Lyons, the metropolis of the French silk industry, possessed in 1685 nearly 12,000 looms. A century later, the annual produce of silk weighed 15,000 cwt. In Germany the rearing of the silk-worm and the manufacture of silk were the industrial fruits of the reception given to the French exiles. Silk costumes soon became the ordinary wear of the burghers. Berlin alone, in 1771, manufactured silk to the value of £180,000, and had 21,000 spindles at work.

The discovery of America was destined to give a mighty impulse to the textile industries. The capability of its soil in many parts for the growth of cotton was, when once discerned, speedily made available. Previously to the year 1774, fabrics made entirely of cotton were not used in Europe. New supplies, amounting in 1790 to 267,857 cwt., now began to arrive from America, and these were nearly monopolised by England. Various inventions had prepared the way for utilising this fresh bounty of nature. Jurgens, in 1530, had superseded the distaff and spindle by the spinning-wheel. John Kay, by his flying shuttle, made one hand perform the work of two, thus facilitating the working of the increased quantity of yarn produced by the spinning-wheel. Notwithstanding national prejudices and fiscal impediments, cotton fabrics quickly became the common dress of the labouring poor.

The mechanical process of spinning consists in drawing out the loose fibres of the carded wool in regular and continuous fleecy rolls, called rovings, or slivers, and in combining these rovings into threads, which in their turn are stretched and twisted into fine yarn. The manual process was tedious, and capable of producing only one thread.

So laborious was the work that, even with the utmost industry, it was not possible for the spinner to "reel off" more than a pound of yarn in a day. The idea of a combination of spindles, revolving vertically instead of horizontally, is said to have occurred to James Hargreaves from the accidental circumstance of the overturning of a spinning-wheel in such a manner that while lying on the ground the wheel and spindle continued to revolve. The idea was turned to good account, and in about 1764 resulted in the spinning-jenny. The first machine was made for eight rovings and eight spindles, instead of one, as in the old wheel; but the principle admitted of indefinite expansion. In 1770 Arkwright invented machinery by which cotton was carded, roved, and spun with astonishing quickness and precision. This was surpassed in 1779 by the genius of Samuel Crompton, who, combining the advantages of Hargreaves' spinning-jenny with Arkwright's spinning-frame, produced the spinning-mule. Arkwright's machinery was not so suitable for the weft of cotton fabrics as for the warp; but the mule was equally well adapted for weft and warp. The mule came into extensive use when Arkwright's patents lapsed in 1785. The vastness of the results gained by its adoption may be judged of from the fact that 1,000 spindles can be easily managed by a single attendant, and that each spindle will produce many times more yarn than was produced under the obsolete system of the spinning-wheel. Such is the perfection to which the mule has since been brought, that the spindles revolve about 4,000 times a minute, and yarn is now spun of such fineness that a pound weight has formed 1,500 hanks, which, if drawn out, would extend nearly 500 miles.

These improvements originated in connection with *cotton*, but it was not until the eighteenth century had closed that machinery was applied to the woollen and linen manufactures, owing to the greater difficulty of manipulating the fibres of wool and flax. After many efforts, machinery

was modified and adapted, and the progress of the former manufacture grew to be second only to that of cotton.

Machinery for spinning flax was even slower in development than that used for wool, nor did it wholly supersede hand-work in England until the year 1830. The difficulties to be surmounted were so great that a premium of 1,000,000 francs, offered by Napoleon to the successful inventor of a machine, was never awarded. Nevertheless, machinery now produces twenty-fold as much yarn as would be possible by hand-labour, and about 2,000,000 spindles are in operation in England. In Ireland, however, hand-labour still prevails amongst the cotters.

There are now in the manufacturing districts of the British Isles about 30,000,000 spindles, producing yearly in the three materials 1,000,000,000 lbs. of yarn. This is equivalent to the hand-labour of 30,000,000 spinners. The number of hands actually engaged is less than three-quarters of a million.

Invention did not stop at spinning-frames. The extraordinary increase in the production of yarn demanded new and improved modes of weaving. The improvements in spinning machinery were the theme of conversation in all ranks of society. The Rev. Dr. Cartwright, of Kent, who till then had never been a mechanician, saw that the operation of hand-weaving was confined to three movements, which might possibly be imitated by machinery. In 1785 he produced his first design for the power-loom, which worked its way to success through repeated failures and modifications. There are now in England 300,000 power-looms, which, with the improvements introduced in 1825 by Roberts, of Manchester, are amongst the most beautiful examples of machinery applied to manufactures. Perfect as the power-loom appeared, it was surpassed in ingenuity by Jacquard, a Frenchman, who invented, in 1801, a self-acting loom for the weaving of brocaded or figured silks. By piercing the pattern in holes on thick cards, he avoided the tedious

process of drawing, and produced mechanically the most complicated designs. Jacquard was at the outset better appreciated in other countries than in France, where his machines were destroyed by ignorant artificers. To use his own words, "The iron was sold for iron, the wood for wood, and I, its inventor, was delivered up to public ignominy." He lived, however, to see the Jacquard loom adapted to the making of carpets and shawls, and it has since been applied to the weaving of woollen fabrics, coloured damasks, embroidery, and figured ribbons. Neither length nor breadth of fabric interposes any difficulty with this marvel of human skill. Its adaptation to carpets and shawls has enabled manufacturers to compete, at a greatly diminished cost, with the carpets of Persia and Turkey and with the shawls of Cashmere, in beauty and complexity of design, as well as in the quality of the fabrics.

At the Exhibition of 1851, moreover, prize medals were awarded to inventors in Austria and Prussia for still greater developments of the capacity of the Jacquard. Raised patterns, both simple and complicated, are now embroidered equally well on the heaviest carpets and on the lightest muslin curtains; and an improvement in the "needle-loom," as it is called, made by an artificer of Lyons, decorates both sides of the muslin, and operates upon thirty or forty repetitions of the pattern. Machines of very varied kinds are employed for the after processes connected with weaving, from the singeing apparatus, which removes the down or irregular nap from the surface of the woven texture, to the packing engines, which compress and bind the finished fabrics into bales for transmission abroad.

The cotton-gin, an American invention, by Whitney, in 1793, by which the seeds are readily separated from the fibre, was the great stimulus to the cotton culture in the Southern States of the Union. The subsidiary processes of washing, rinsing, calendering, drying, mangling or pressing, measuring, and folding are all now performed by self-acting

machinery, amongst which one of the most perfect and remarkable is that of the centrifugal steam drying-machine, invented by Penfold, in 1836. The fulling-mills, for woollen textures, and brushing-machines deserve to be mentioned. Machines for printing woven fabrics have been so perfected as to make this branch of the cotton industry scarcely second to that of weaving or spinning. Machines are also employed in arranging the warp for the loom, so that the threads may lie parallel, and of equal length, upon the cylinder or weaving-staff. This object was still better achieved by the process of Ross and Radcliff, of Stockport, who passed the threads through paste or size, dried them upon hot cylinders, and thus stiffened them for weaving.

The manufacture of the cards by means of which woollen and cotton fibres are disentangled and laid smooth previously to being spun is remarkable, as an example of machinery made to make machines. These cards consist of stout buff leather, closely set with myriads of fine steel wire hooks, the whole of which are now planted or set in an instant, while the leather is highly distended to receive them. In a single hour 9,000 cards can thus be furnished, each of which would be a week's work for a labourer. Hargreaves is said to have erected the first cylindrical carding-machine.

Silk machinery has also been improved, and the annual value of the silk ribbons produced in France at the present time amounts to 50,000,000 francs. Switzerland also produces ribbons valued at 28,000,000 francs.

Hosiery and lacework have not been left in the rear of improvement. William Lee is said to have gained the idea of the stocking-frame from watching his wife at hand-knitting. He observed that the loops in knitting were raised by the worker's fingers, and his object was to devise by mechanical means a series of artificial fingers, which should multiply the number of loops. Queen Elizabeth, in whose reign Lee's invention was made, praised him for his ingenuity,

but declined to grant him a patent, and discouraged the use of his machine, on the ground that it took away the means of living from her poor subjects. A picture is in the possession of the Stocking-Weavers' Company, in Red Cross Street, London, representing Lee in the act of explaining to his wife the principles of his knitting-frame, and its superiority over the needles she is using at the time. An inscription beneath states that, "In the year 1589, the ingenious William Lee, M.A., of St. John's College, Cambridge, devised this profitable art for stockings (but, being despised, went to France), yet of iron to himself, but to us and others of gold, in memory of whom this is here painted."

Knitting and netting differ from weaving in the use of only one thread instead of cross threads, to form the texture. Netting is a mode of entwining the thread so that each mesh is fastened with a knot. In knitting, the loops or meshes run on without knots, so that, if one loop slips, the hole continually enlarges by the giving way of the adjacent loops; thus a knitted stocking may, by drawing a single loop, be wholly loosened, while a piece of lace, or a fisherman's net, would require every mesh to be untied. Stockings were at first knitted in pieces, which had to be joined and shaped. The stages of improvement were, however, rapid, and stockings without seam issued direct from the loom. There are now in England 50,000 looms working on this principle; the stockings produced are valued at £4,000,000 annually, and the number of stockingers exceeds 100,000. Similar looms in France produce every year 18,000,000 pairs of cotton and 5,000,000 pairs of silk stockings. In some few places the old knitting-frame is still in use, as, for example, in Chemnitz, where about 3,000 masters, employing each an average of ten workers, have not yet accepted the new machinery; and also in the Scotch hosiery towns. In fact, it is doubtful whether machinery can yet do the best work.

The bobbin-net machine was introduced by Heathcote, in 1809; and, in combination with the Jacquard, it revolutionised the lace-trade. Dexterous women could make no more than a few inches of narrow lace in an hour. The cost was consequently excessive, and a lady's veil of Honiton lace sometimes cost 100 guineas. Lace-making machinery, however, was so far perfected by the year 1824 that a veil, scarcely to be distinguished from Honiton, could be made for a hundred pence. The bobbin-net machine, compared with hand-labour, possesses a six thousand-fold power of production. One machine will turn out 40,000 square inches of net in an hour. Nottingham is the principal seat of the English lace-trade. In 1850 there were exported from this town more than 140,000,000 yards of lace, half of which went to the Continent and half to the British colonies.

The art of bleaching has also been vastly improved. So little was formerly understood about bleaching in Great Britain that it was usual to send the material to Holland to be bleached, an operation which caused a loss in time of from seven to fourteen months. The commercial name of these goods is still "Hollands," or "brown Holland." The introduction of chlorine into the process completely transformed the art of bleaching, hitherto accomplished by exposing the stuffs to the action of air, light, and moisture. Bleaching establishments of great extent arose. The works at Ridguan, near Bolton, bleach daily 16,000 pieces of cotton of thirty yards each, consuming in the process sixty tons of coal. As an example of expedition, 1,400 pieces of grey muslin were received at the bleacher's, returned to the manufacturers, and shipped to a foreign market, all in the course of two days. Linen goods, however, require several processes, and take a longer time in bleaching. The largest linen-bleachers are in the neighbourhood of Belfast. At the works of Messrs. Bray and Son, at Cotton Mount, 500,000 pieces of linen are bleached annually. The average business

of the neighbouring establishments, of which there are about thirty, is not much less than 100,000 pieces each.

Steam-power was first introduced into a cotton-mill in Manchester, in 1789. It gained ground but slowly, and until after the present century had commenced steam was not generally used to drive the machinery of the textile manufactures. Such have been its advances since that one engine is now made to drive 50,000 spindles. With multiplied agencies for the working up of the raw material, an imperative demand arose for larger quantities of it. The world was searched for new sources of supply, while the old ones, by more skilful means of production, gave an increased yield of an improved quality. New substances were brought into requisition, amongst which were jute, the produce of an East Indian plant to blend with or to substitute for flax and hemp, China grass, and New Zealand flax; together with mohair, from the Angora goat, and the wool or hair of the alpaca and the vecuña. The strength, lustre, and fineness of merino wools have been much increased by new methods, discovered by Johann Louis Grann, of preparing the fibre for combing. A process has been invented by John Mercer, whereby cotton can be made to assume the character of wool. Claussen, in like manner, has succeeded in imparting to flax fibre the properties of cotton. Silkworm culture has so much improved that from 1,000 to 1,500 yards of thread are often wound off a single cocoon, where 300 or 400 yards in former days would have been thought a good yield.

For the statistics of cotton, wool, flax, and silk, which have reached dimensions beyond the imagination of a former generation, see "Natural History of Commerce," p. 337 *et seq.*

Besides beauty of texture, and great abundance, unparalleled cheapness is a feature of the present age. Woollen cloths are now often used for cushions and other purposes for which leather was once employed. The finest qualities of linen fabrics, such as damasks, dowlas, French lawns,

and cambric, though better made, bear no comparison in price with their former cost. A bundle of linen yarn, which in the year 1700 cost 29s. 5d., can be obtained for 6s. 8d.

SECTION II.—THE DYER.

The discovery of America influenced the dyer's art so materially that its proper development dates from that event. The Spaniards found the Mexicans in possession of woven fabrics of black, red, yellow, green, and blue. The red was of the most brilliant character, being the cochineal of modern art. This dye rapidly took the place of the kermes. Its annual consumption now reaches many millions of pounds avoirdupois. The cultivation of the particular cactus upon which the insect feeds has also spread throughout the corresponding climatical zones of the Old World. Cochineal has proved invaluable, not only as a simple dye, but for its power of combining with other substances, in producing splendid colours. By the union of cochineal extract with nitre, hydrochloric acid, and common salt, a process invented in 1650, by Cornelius Drebbel, at Alkmar, a new dye was furnished, now familiar to us by the name of scarlet. Another red contributed from the insect world is that known by the name of lac-dye, obtained from a resinous insect exudation called gum-lac. Madder is also in request as a red dye, in imitation of Turkish red. Safflower, the petals of crocuses grown in Turkey, yields beautiful cherry tints. The blue dyes now used are chiefly of modern introduction. Before the use of indigo, known to the Romans only as a pigment, and first brought from the Dutch Indies in abundance about the middle of the sixteenth century, woad was in general use in Europe. Despite every effort to encourage the use of the ancient woad, the beautiful tropical product, indigo, would soon have displaced it as effectually as cochineal had displaced kermes, but for an opportune discovery—a combination of the two dyes was

found to give a more permanent colour than either alone. Indigo has been made the basis of several new blues, one of which is the Saxon blue, used by silk-dyers, procured by treating indigo with sulphuric acid. The Prussian blue, discovered by Diesbach, at Berlin, in 1710, is a beautiful dark colour, now prepared from yellow prussiate of potash, which is made from dried bullocks' blood and carbonate of potash, sulphate of iron, and nitric acid. Paris blue is Prussian blue prepared from perchloride of iron and yellow prussiate of potash. Smalt, a pale blue colour, takes every depth of shade by admixture with Socotrine aloes; and azure, a bright, pleasant blue, is obtained from verditer, and also from indigo.

The older yellow dyes were confined to the dyer's weed, fustic, turmeric, saffron, and the saw-wort. To these were added, in 1775, arnotto, and the still more important substance known as quercitron, both indigenous to the New World. This latter dye admits of many modifications, and, when combined with muriatic acid, tin, alum, and tartar, produces, according to the proportions used, every shade into which yellow enters, from the deepest orange and amber, to the faintest lemon tints. A series of green dyes is also obtained by mixing quercitron with the various blues.

Till recently, the chief dye-stuffs have been of vegetable origin. Chemical researches have of late, however, furnished so many artificial dyes that the present time promises to be a new starting-point in the history of the art. Aniline, first obtained by Dr. Stenhouse, from lichens, in 1848, is now made on a large scale from coal-tar, for the production of mauve, magenta (rosaniline), various fine blues, and other beautiful colours. Aurine, or rosolic acid, is also a dye obtained by chemical processes, and of somewhat similar origin; this dye is used to a considerable extent in the place of madder for Turkey red dyeing. The use of the gas-tar dyes has given a resplendency to coloured fabrics

never before approached. Chemistry has also indefinitely enlarged the resources of the art, by showing how to produce varieties and shades of colour extending through the whole range of the prismatic spectrum, and has enabled the dyer to fix and render durable many of those vegetable dyes whose fleeting brightness formerly lessened their utility. Along with these improvements, the nature of the substances to be dyed has received careful and scientific investigation. Wool, silk, linen, and cotton so far differ from each other that they all require different modes of dyeing. Animal fibres were observed to take dyes in their original beauty and permanency, while to linen and cotton the same preparations imparted only dull and fading colours. Chemistry adapted the processes to the substances operated upon.

Amongst the recent achievements of the art are the means adapted by Mercer for giving to cotton and linen colours as bright and as beautiful as to wool, and the ingenious expedients by means of which there can be imparted to woven fabrics numerous shades, separate or in combination.

Mordants, or "biting" materials, possessing a common affinity for both the texture to be dyed and the colouring substance, had hitherto, from want of scientific culture, been limited to alum, cupric and ferric sulphates, the stannic oxide, potash, lime, and hydric nitrate. As the result of chemical experiment, many acids, salts, and metallic oxides have been discovered to possess similar and even superior properties. These mordants unite with the colouring matter of the solution in which the texture is immersed, to form insoluble compounds in the substance of the cloth; and by the previous application of various mordants, single textures may now, at one dip, be dyed several brilliant patterns and colours; peculiar shades may be produced, the most diverse fabrics may be dyed together, and the most perfect fixity given to the colours.

The art of dyeing has been further promoted by improved modes of preparing the dye-stuffs. Machines have been introduced for the grinding and extraction of many of the dyeing principles on the spot where they are produced. Log-wood, quercitron, Guinea red-wood, and gall-nut are now rarely brought over in heavy and costly bulk, but as dry powders, occupying but little space.

Allied to dyeing is cloth-printing, or the art of impressing coloured figures or patterns upon woven tissues, a practice which is more recent than that of printing on paper. Augsburg was one of the first cities in which this industry was pursued. Hoffman, a printer of fustians, was mentioned in 1523, but 120 years later there were only sixteen persons engaged in the operation. With the advance of the cotton manufacture the printing of the fabric became more common. At first the operation was tedious and clumsy. It was conducted by means of blocks, upon which the pattern was cut, in the same manner as paper-hangings are now printed, and as general printing is still carried on in China. The various colours were applied by successive impressions. Beel's rolling-press, invented in 1785, by means of which any length of cloth passing under an engraved roller was printed in a few minutes, was a great improvement upon the slow process of hand-work. Much ingenuity has been exercised in the construction of these machines, which now, by means of five or six rollers in succession, are made to impart, with great exactitude, as many colours to one tissue. A method has also been invented of rapidly engraving these rollers. Hand-printing was not, however, entirely dispensed with until Perrot, of Rouen, in 1834, superseded it by a machine which, by alternate action, covered the raised pattern of the mould with colour and also impressed it on the cloth. These improvements have been followed by many others. By a further scientific advance, the cylinders are now engraved by means of galvanism, and the process of imparting colours to woollen fabrics has become so purely scientific that every

large dyeing and printing establishment has a skilful chemist and an extensive laboratory. At the present time, the printing of woven cloths generally, and calico-printing in particular, have reached a high degree of perfection.

The superior adaptability of wool for dyeing is strikingly displayed in the material called Berlin wool, the beauty of which, together with its durability and cheapness, has driven the coloured materials of English manufacture, common between 1820 and 1830, almost out of use. It has also done much to revive in every civilised country the ancient feminine occupation of embroidery. Berlin wools of every gradation of shade now employ the skill of far more hands than when embroidered work was confined to silken tapestry and carpets.

Bleaching works, dyeing works, and cloth-printing works have grown to colossal magnitude in Great Britain, while the art of the designer has also been largely developed. Paris, which once led the fashions of Europe, and still powerfully controls them, was the first city to cultivate design as a distinct art. Schools of design have since sprung up in Germany, in which instruction has been given since the year 1813. In Berlin there are manufacturers of patterns for embroidery employing from sixty to a hundred colourists. There are eighteen publishers of books on embroidery, some of them having in stock more than 30,000 patterns. Within the last generation great efforts have been made to spread a knowledge and love of art throughout the United Kingdom, a movement which the late Prince Consort had greatly at heart and did much to promote.

France retains the foremost place in designing patterns for silk, but is, however, closely approached, not only by England, but also by Germany and Austria. Berlin, Vienna, Augsburg, Chemnitz, Elberfield, Ludwigsburg, Lorrach, and Eisenburg, all have works for dyeing and printing in colours.

SECTION III.—THE TAILOR AND DRESSMAKER.

From the close of the fifteenth century sumptuary laws became a dead letter, and distinctions of rank were no longer rigidly marked by costume. Geographical discoveries had vastly enlarged the area whence materials for clothing could be obtained. With the increased supply of materials, with improvements in the manufacture, dyeing, and printing of cloth, and with a greater perfection in needles, the tailor's craft received a great development.

In summarising its history, we are led to observe that its proportions in recent times have expanded very much beyond those of previous ages. Several of its members have made themselves noteworthy, and become wealthy in proportion. Stultz is distinguished as one who made an enormous fortune while holding the appointment of tailor to the Court of St. James. The Grand Duke of Baden conferred on him the Knighthood of Ostenburg.

The yearly value of articles of tailoring made in Paris exceeds £4,000,000, about one-tenth part of which is for the export trade; 10,000 journeymen tailors and 4,000 women find employment there. This industry is of a still more extensive character in London. Over 30,000 journeymen are occupied. Ready-made clothing is a branch of the art which within the last few years, especially since the employment of sewing-machines, has received a great development, nowhere, however, so great as in our metropolis. Much of the trade has arisen to supply our large colonial demands for clothing, but its remarkable cheapness has also encouraged the growth of a large home consumption.

In the earlier stages of the tailor's craft, women's dresses equally with men's were comprised in the one occupation; the art of dressmaking, as distinct from tailoring, has sprung up only within the nineteenth century. In England the women's tailor has given place to the female dressmaker, but in Germany he has not yet disappeared. Dressmaking has in

turn been subdivided, and the milliner's art made distinct. No milliners in the world are equal in skill and taste to those of Paris. Every requisite for the toilet and wardrobe; chemisettes, ruffles, caps, bonnets, dresses, and mantles, are here prepared with the highest finish.

Manufacture of Artificial Flowers.

This branch of art, now an extensive industrial occupation, arose in Italy in the beginning of the eighteenth century, whence it spread to England and France especially. Not only are the familiar blooms of the rose, lily, fuchsia, tulip, and mignonette imitated, but even the rarest and most grotesquely-formed and delicately-coloured orchids are so faithfully represented as almost to deceive the experienced botanist. Buffon, the great naturalist, was forced to admire the productions of Madame Genlis, and, still more recently, professional men have borne testimony to the surprising accuracy with which nature is represented.

Artificial flowers can be made from the plumage of those birds whose feathers possess beautiful and brilliant colours. The plan of imitating flowers with feathers has long been known to the savages of South America. In France fine cambric is used in the manufacture, whilst wax is largely employed for the same purpose in England. In the Great Exhibition of 1851 there were elegant roses constructed out of the most diverse materials, such as shells, hair, rice-paper, spun glass, beads, coffee, chocolate, cotton, soap, wood, marble, porcelain, and common earthenware. They were the products of France, Austria, Hamburg, Sweden, Portugal, Madeira, Mexico, the Channel Islands, and the British colonies.

In this branch of manufacture the French hold the first place, especially in the making of cambric flowers. France exports annually to the value of 1,000,000 francs (£40,000), of which amount England and the United States together

purchase more than half. So long ago as 1847 the artificial flowers produced in France were valued at 11,000,000 francs. Paris alone possessed forty-eight manufactories, employing upwards of 6,000 hands. There are in Berlin more than 800 female flower-makers.

SECTION IV.—THE FURRIER, TANNER, GLOVER, AND FELLMONGER.

Caoutchouc and Gutta-percha.

The leather and fur handicrafts shared the impetus which industry generally received from the great events at the close of the fifteenth and the beginning of the sixteenth centuries. The geographical discoveries vastly enlarged the area whence furs and hides were drawn, and the increased supply of raw material for manufacture far more than made up for the gradual extermination of the wild animals of Europe. While the native resources for furs were diminished, the progress of pastoral and grazing husbandry provided innumerable skins and hides. Cattle-rearing was attended to in every part of Europe, and with such great results that 200,000,000 sheep are now computed to exist. In England there are 2,000,000 horses, besides an immense number of horned cattle. Together with these domestic supplies, every region has been explored in quest of peltry, skins, and hides. Since the settlement of Canada, the chief source of furs has been the northern parts of North America, under the government, until recently, of the Hudson's Bay Company. The hunting-grounds of the Old World are in the corresponding polar latitudes, but they do not vie with the inexhaustible resources of British North America. The Russians, however, pursue an extensive and active trade in Siberia, disposing of the produce in the great fairs of Novgorod and Leipzig. London is the great fur emporium, being the official centre of the dealings of the Hudson's Bay Company, whose vessels arrive about September, and

whose freights are disposed of by public sale in March. Their most expensive and beautiful fur is that of the sea-otter, which is so rare that it costs at first hand £20. The company displayed at the Great Exhibition of 1851 an interesting and instructive series of examples, amounting to several hundreds in number, of all the fur-bearing animals in their territories. The produce of Russia equals the gross extent of the English trade. The highly-valued sable is the chief, of which 25,000 skins are annually sent to the fair at Leipzig, whence European dealers obtain their chief supply.

Improvements in the methods of tanning and in the further operations of the leather manufacture in every branch have kept pace with increased supplies. Before the end of the sixteenth century, the Hungarian process of tawing was practised throughout the continent of Europe. Two tanners in the Netherlands first acquired the method, and, in 1584, introduced it at Neufchatel. A French establishment was started, in 1628, at St. Cloud, but removed four years later to St. Denis, whence the Hungarian method of preparing leather soon spread through every French province, as well as into Germany. New tanning substances were sought after when oak-bark could no longer be obtained in sufficient quantities. The sawdust of the oak was found to contain the tanning principle, and valonia, or the acorn cup of a peculiar species of oak, was also used. Numerous other vegetable products, such as ferns, the barks of the chestnut, willow, and larch, water from the turf-moor, sumach, myrtle, and mastic, were brought into requisition as well as exotic extracts, such as *terra Japonica* or *catechu*. A simple acceleration of the tanning process has been obtained by heating the ingredients in which the skins are steeped.

The English stand at the head of the leather manufacturers of the world, both for the vastness of the industry, and for the high quality of the leather produced. An Englishman, Macbride, at the end of the last century, invented a method of shortening the time required for the

chemical changes which hides undergo in the process of tanning. At first this economy of time was accomplished at the cost of a brittleness imparted to the leather; but Seguin, a Frenchman, has since so much improved upon the method that the thickest hides are now prepared in fewer weeks than it once took months; and skins are passed through every operation in a period varying from a week to a fortnight. The quality of the skin has much to do with the kind of leather produced. The superior feeding of English cattle gives their outer coating a finer and closer grain, the ox-hide used for soles being of the most excellent quality, and of the most desirable elasticity. In Germany, however, where the leather trade is also very important, the hides are spongy and coarse as compared with the English, while they are often dark and brittle, and so hard that the edge of a sharp knife will not penetrate their surface.

Many new methods have been introduced in order to increase the beauty of the leather, or to fit it for special purposes. Two such processes are those of compression and of polishing. By the first the solidity of the hide is greatly increased; by the second the surface is not merely polished, but the whole is rendered impervious to water. Patent or enamelled leather is manufactured very largely in England. Leather to which a polish is to be repeatedly given by means of blacking has one surface prepared of a dull black colour. Besides the vast quantity thus either polished or blackened, dyed leathers are brought to a point of excellence as perfect as in the case of woven textures.

The famed leather-work of the Arabs or Moors is now imitated, and in some respects surpassed; and the descriptive terms which arose with those ingenious people, "cordovan," "morocco," and "shagreen," are now applied to the products of modern Europe. English morocco has been manufactured since the end of the seventeenth century; that of France is of peculiar excellence, and 300,000 goat and 1,500,000 sheep-skins are annually prepared there. One of the most

skilful adaptations of machinery to leather manufacture is that of the skin-splitting machine, by which the skin of a sheep or calf is cut into two or even three sheets, each part serving a different useful purpose. To this machine the art of glove-making owes much of its extension, inasmuch as skins which were unfit before are thus rendered sufficiently thin, and can be used like the skins of kids.

Since the duty on leather was removed, in 1830, the value of this home industry has greatly increased. Probably, little short of 100,000,000 lbs. of leather are now annually produced, worth more than £6,000,000 sterling, and this, again, is calculated to be but a third of the ultimate value of the finished articles. Changes in industry have with the course of time modified the relative prominence of different branches of the art. Cloth, as a material for dress, has in many instances superseded leather. Leather breeches, for example, once universally worn, are now only in use for riding. In the minute subdivision, also, to which labour is now subjected, many products, such as umbrellas, corsets, and fans, all of which were once included in leather-work, have become objects of independent handicrafts.

The wearing of gauntlets for warlike purposes dates from time immemorial; but the custom of donning gloves as a regular part of attire began in the reign of Louis XIV., when hand-coverings of leather, wool, cotton, or silk, became the rigorous requirement of fashion. The leather gloves which were most in request were made of deer-skin or chamois-leather, but since that time the plan of tawing kid-skins with milk, wheaten flour, salt, and the yolk of eggs has been much in vogue. The leather resulting from this process is so beautifully soft, glossy, and elastic as to cause the manufacture to be of exceeding value. It is extensively pursued in England and Germany, whilst in France it forms a national industry. It is computed that there are 36,000 glove-makers in France. The kid-skins furnish, one with another, material for two pairs of gloves; and from

6,000,000 to 7,000,000 are used in the manufacture every year. In colour, shape, and delicacy, French gloves surpass all others, and there is a demand for them wherever European tastes prevail. The success of the French has undoubtedly resulted from their persistent efforts to attain excellence, for within the first half of the present century 113 patents for inventions and improvements were registered. Amongst these is Jouvin's steel die, by means of which, at one stroke, a number of gloves can be cut out precisely the same in size. Messrs. Jouvin and Doyon stand at the head of their art, and annually dispose of about 10,000 dozens of gloves, of the value of £6,000. Their trophy of patterns in the Exhibition of 1851 was the most remarkable display of the skill of the glover ever witnessed, the examples of colour alone numbering close upon a hundred distinct shades. The number of operative glovers in England is estimated at 40,000. The best German workmanship is found in Berlin, into which city the art was introduced at the beginning of the eighteenth century. In Luxemburg the annual produce exceeds 1,000,000 pairs. In Vienna 180,000 dozen are made by 4,000 workpeople. A distinct but allied branch of this art is that of the fellmonger, revived in this country, although ancient in its origin. He prepares sheep-skins, with the wool attached, for rugs and superior mats. We read of the "rams' skins dyed red" as used in the Tabernacle (Exod. xxvi. 14). The modern process of manufacture, in which the English excel, on account of the special suitability of the coarse wool skins of Leicestershire and Lincolnshire, and of the lustre of the wool, consists in thoroughly extracting the natural grease, and then producing leather by means of alum and sumach. The wool is afterwards dyed with bright and permanent colours. These rugs are much admired in our own country, and an extensive exportation also takes place, especially to the United States and Canada.

The qualities which made leather valuable for some

purposes, unfitted it for others. It was not thoroughly impervious to moisture, and endless devices were tried to render it so. Meanwhile, there existed, secreted in the tissues of several plants, juices which had the property of hardening when exposed to the air. These substances are now known as caoutchouc and gutta-percha, the former produced in the East Indies and in South and Central America, and the latter in Further India and the East India Islands. Gutta-percha is quite a recent discovery. Caoutchouc, gum-elastic, or india-rubber, so called from its first use for rubbing out pencil marks, was, however, described by the naturalist De la Condamine as long ago as 1735; its employment, nevertheless, for industrial purposes is almost as recent as that of gutta-percha. Its first application was to render woven textures waterproof. This was accomplished either by spreading a solution of caoutchouc over the surface, or by placing it between two layers of the texture, and submitting the whole to pressure. The name of Mackintosh, who, with Hancock, in 1820, made the first successful attempt of this nature, is still identified with the waterproof clothing now in common wear. Among the many useful things that began to be made were elastic webs for bracelets, braces, and garters. The French greatly improved upon these methods, by devising a plan whereby the prepared caoutchouc could be separated into fine threads, ready at once, or after being wound round with silk or cotton, for weaving like common threads. The preparation of these threads is now a distinct business, the manufacturers selling the produce upon spools of different sizes.

The defects of india-rubber were that it became soft and sticky, or lost its elasticity. These were remedied by an invention of Hindersdorf, of Berlin, who, by a process of vulcanising the material, or preparing it with sulphur, lessened its tendency to soften, while retaining its elasticity. Messrs. Mackintosh and Hancock, in England, and Goodyear, in the United States, extended the method of vulcanis-

ing caoutchouc. Goloshes, or waterproof shoes of pure india-rubber, were an invention of Goodyear, in 1830; they have largely superseded pattens and clogs, and are manufactured, chiefly in the United States, to the number of 4,000,000 pairs annually, 3,000 pairs a day being the production of a single firm. Since 1836 india-rubber has been employed for carriage springs and tires, noiseless axles, elastic mats, balloons, tobacco-pouches, air-cushions, sheets, mattresses, globes, waterproof paper, saddlery, tarpaulins, portable baths, pistons for pumps, valves for engines, lifeboats, tubing, the buffers of railway carriages, the joints of metal and earthen pipes, washers, combs, and indestructible playthings. The German india-rubber factories are very extensive, and the goods produced are equal to the best wares of England or America. In France, also, the trade is pursued with skill and activity. The progress of the industry in England may be judged of from the fact that the importation of caoutchouc in the twelve years after the introduction in 1830, of Mackintosh's process, rose from 30,000 lbs. to 80,000 lbs. At the same time, in the United States, a capital was employed estimated at £2,000,000 sterling.

Gutta-percha possesses some of the properties of india-rubber, and others peculiar to itself. It is not so easily acted upon by chemical agents, and is thus adapted for vessels meant to hold acids. In 1845 there were scarcely 20,000 lbs. brought into Europe, but when its qualities became known the importation so increased that the annual supply now exceeds 4,000,000 lbs. It is not too much to say that to the discovery of gutta-percha we owe the present dimensions of our grand system of marine telegraphy, since no other substance could serve so cheaply and so well for the protection and insulation of the wire. For many other purposes, also, such as the pressing rollers used in flax-spinning, it is peculiarly suited; as also for utensils and articles on board ship, such as buckets, sailors' hats, speaking-trumpets, waterproof clothing, and life-

boats. In warm water it softens without becoming sticky, and its plastic power while in this condition is so great that it will take any form, or receive the most delicate impression, retaining the same when cold; it has, therefore, become an indispensable material to the decorator, who uses it in lieu of carving and modelling for friezes, panels, and enrichments. Ornamental furniture, likewise, such as writing-desks, work-boxes, and picture-frames, are largely made of gutta-percha. As light, tough, durable, and elastic as leather, as noiseless as india-rubber, and with a great capacity for combining with other substances, and for developing new useful properties, this simple hydro-carbon has already been applied to a great variety of useful purposes, and bids fair to become still more extensively employed.

SECTION V.—THE SADDLER.

The saddler manufactures such articles as are used in the equipment of horses and vehicles. Formerly, however, the craft included the making of trunks and knapsacks. Since the sixteenth century, costly riding-gear has gradually fallen into disuse; simplicity and lightness, consistent with the requisite degree of strength, being preferred. A new impulse was given to saddlery by the introduction of coaches, and very important service has been rendered to the art by recent improvements in travelling. The saddlery trade in Germany is very extensive; Prussia and Bavaria alone contain 1,200 saddlers and harness-makers, who employ 6,000 workmen and apprentices. In 1778 the attempt was made, by Navarre, in Paris, to construct saddles with stirrups so arranged as in case of a fall to prevent the rider from hanging, and consequently being dragged along the ground. The invention, however, has not been brought into common use. A remarkable saddle was shown amongst the collection in the Great Exhibition of 1851, which was capable of being taken to pieces and

put together again, so as to fit the back of any horse. Articles such as straps, bags, girths, saddle-cushions, and bridles are at present often made of gutta-percha and india-rubber, and are preferred to those made of leather, inasmuch as they are more waterproof and elastic. There is a manufactory in Vienna which works up annually into saddlery more than 15,000 cwt. of india-rubber.

SECTION VI.—THE SHOEMAKER.

In the sixteenth century splendour in dress characterised every European state. Sir Walter Raleigh's boots, at the Court of Queen Elizabeth, sparkled with jewels worth £6,000. Pantaloons, which were the common costume of the age, brought into use the slit-shoe, as best in accordance with the dress. To suit the puffed pantaloons, the flaps on the shoes were proportionally enlarged, and differed from the shoe itself both in material and colour. Improvements were made in the beauty and convenience of the puffed slit-shoes, which continued to be worn down to the seventeenth century. Attempts were made, however, to suppress these fashions by sumptuary laws. In 1612, John George, Duke of Saxony, prohibited velvet boots, shoes, or slippers braided with gold or silver, or in any way decorated with precious metals, stones, or pearls, to aldermen, mayors, bailiffs, stewards, or judges, or to the ladies of the families of doctors and professors.

During the Thirty Years' War, an imposing style of boot came into military fashion, the leggings ascending nearly to the knee, whilst two exterior wide-mouthed tops flapped over from the leg, after the manner of funnels.

Shoes as at present worn were introduced about 1633, and were first fastened with buckles in 1668. They became universal for men's wear before the close of the century. The "Steckel shoe," of French design, made of the choicest materials, was worn by ladies throughout Europe. The

English buckle-makers petitioned without success, in 1791, against the use of shoe-strings. The French Revolution ushered in a new era of taste. Changes in fashion, but of a minor character, have since arisen. The heel of the boot has sometimes been worn high and sometimes low, the toe has been wide, or narrow and pointed, and the sole has been wide or confined, but no flagrant violation of the laws of health or of symmetry has been finally accepted.

The increased supply of leather, arising from the enlarged area whence skins are obtained, and the improved facilities in their preparation, have given an impetus to the shoemaker's art. The patent or polished leather, of which many boots are now made, is so excellent in quality that the polish lasts as long as the leather.

The seemingly unimportant invention of "blacking" has told favourably upon the craft. The quantity of blacking consumed is well-nigh incredible, and its manufacture is extensively carried on in England and elsewhere. The firm of Day and Martin for a considerable time had practically a monopoly. Nearly 1,000 dozen pints of blacking, equal to 150 barrels, were sent out daily from their establishment. The utility of this substance is twofold, inasmuch as it acts as a preservative to the leather, and gives at the same time a beautiful polish.

A great disadvantage under which shoemakers labour is the position it is necessary to assume whilst engaged at their trade; they have to sit in a stooping posture. Many attempts have been made to introduce methods of working in an upright position.

Dumerie, of Paris, exhibited in 1851 an ingenious machine, one which promises to supply the best mode of uniting the parts of a shoe, and also to realise the desideratum of standing labour. The proprietor employs it extensively, and turns out goods from his factory to the value of £20,000 annually. The soles and uppers are

screwed together in a firm and durable manner, neither pegs nor stitches being called into use. Although this plan appears to answer every purpose, little readiness has been shown to copy the system.

England competes advantageously with foreign manufacturers, the boot and shoe industry, chiefly located at and around Northampton, being of great importance. In conclusion, we may safely say that the shoemaker's art has arrived at an excellence leaving little to be desired. Comfort, comeliness, and sanitary laws direct the fashion, and both the craft and the community benefit thereby.

SECTION VII.—THE HAIRDRESSER AND THE COMBMAKER.

It is in the Modern Period, beyond all precedent, that the handicrafts auxiliary to hairdressing have been developed. The age of Louis XIV. was especially favourable to this department of industry. Fashion ruled more arbitrarily than before: the utmost splendour of dress prevailed, the mode of wearing the hair was artificial, and the demand for toilet requisites and the services of the coiffeur increased correspondingly. The ancient Roman peruke was revived, the honour of the revival being due to the "Great Monarch." It was introduced into France and Italy in 1620, and at the Restoration in England it was worn in contradistinction to the Puritan habit of cutting the hair close. In the French Court even woman's "glory" was despised. A hideous structure of pads and cushions, covered with false hair, was erected, which was made still worse by absurd imitations of the battlements of a castle or of the form of a ship. The incongruity was even carried farther, by affixing with pins to these figure-perukes, flowers, lace, veils, and bonnets, sometimes large, sometimes small. There were established in France in 1659, by royal ordinance, 200 peruke-makers and

beard-shavers. Black wigs were at first worn, but when the fashion spread to the middle and lower orders of the people, the great, wishing to maintain an aristocratic distinction, changed the style to a light colour made of more costly materials. An ordinary black wig could be bought for £1; a light wig for ceremonies of state, reaching down to the waist, often cost £200.

Hair-powder, or meal-dust, prepared from wheaten flour, came into use in 1590. With the caprice of vanity, the frivolous Court of Versailles grew tired of light-coloured perukes, and began to use this powder. In riding, the monstrous ends of the perukes were packed in bags, which originated the old term of "bagwig." Powdered perukes for general wear had their day, and in official costumes even now maintain their sway. The bishops of the English Church wore their wigs in Parliament until William IV. came to the throne, when Blomfield, Bishop of London, obtained the King's leave for the members of the bench to discontinue the practice, of which privilege they gradually availed themselves. There was little occasion for concealing the hair with a wig, when it could be as neatly hidden by the aid of meal-dust alone.

Spreading from Paris as a centre, the fashion of powdering the hair was copied in every European State. French friseurs were regarded as great artists, and were patronised at every Court. Along with powdering, the pigtail, or queue, was introduced, and worn by all classes except labourers. Soldiers and sailors were compelled by disciplinary rule to wear both powder and tails. How much wholesome flour was wasted in the many years of the continuance of this absurd fancy it would be impossible to calculate. It is said that in Russia alone the yearly consumption was 100,000,000 lbs.

During the whole period of wigs and powder it was customary to exhibit a smooth face, the whiskers even being clean-shaved. Peter the Great peremptorily enjoined his

subjects, whatever their rank, to shave, and kept officers whose duty it was to cut off by force the beards of those who hesitated to obey. When Europe began to calm down from the convulsions of the French Revolution, it was plain that even in hairdressing nature had asserted its power over the hollow mannerisms and trivialities of the previous period. Perukes, bagwigs, pigtails, powder, and pomade had disappeared in the terrible struggle. The natural hair was worn, whiskers were permitted, and the moustache again appeared.

From the extreme of bad taste, in their pomaded turrets, the ladies of Europe returned to an antique simplicity, adopting first the spiral coil of the Greeks, and then the fashion of the Romans under Titus, enriching their hair with diadems or fillets of jewels. Mediæval modes followed in due sequence, and artistically-wrought combs, copied from jewelled and carved examples, were brought into favour. Until lately there has been little tendency to revert to the meretricious and unreal tastes of the eighteenth century. The hair has been parted down the middle, the long back hair has been wound and fastened in a knot, and the side hair worn in smooth bands uniting behind, or suffered to fall in moderately long curls. The majority of modern changes has consisted of modifications of this graceful, natural, and simple style.

The trade in false hair has, nevertheless, always continued. The finest qualities of hair come from Germany, and produce as much as sixty francs a pound. This is the light-coloured or flaxen hair common to the Saxon race. Good hair, of a darker colour, ranging from thirty francs and upwards, is obtained from France and Belgium. A peasant girl's head yields from three-quarters to one and a half pounds of hair; and in many places is cultivated for the dealer with the same regularity as the fleece of the sheep.

The fashions which called into existence so many hair-

dressers gave rise to a demand for combs of every shape and size, and combmaking expanded into an important craft. The first mention of a gild of combmakers is in 1592, at Nürnberg. In the following century such an extension had been given to the industry that a minuter division of labour was necessitated. The ivory being shaped by one workman, reached the hands of another, who cut the teeth, while a third was employed in polishing the finished commodity and preparing it for sale. Workers in horn had likewise become so well acquainted with the properties of that substance that specimens of their handicraft vied in delicacy and clearness of colour with the tortoise-shell. Nürnberg wares of every variety found a ready market in every quarter of the world. Beautifully worked and perforated horn and tortoise-shell combs were for a long time worn by ladies; and though the high-backed comb has gone out of use, yet the beauty and elegance of the tortoise-shell comb still maintain a hold over feminine choice, and create employment for many artisans. Thousands of combs are exported from Nürnberg for the use of the silk throwsters of Italy.

Commerce has brought to us from new regions materials not hitherto available; and our mechanical age has relieved the comb operative from the wearisome manual labour of cutting and filing the teeth. The apparatus, which cuts out the teeth of two combs in one operation, was invented by an Englishman, named Bundy. It has since been much improved. An adaptation of this machine is used for ivory and boxwood combs, and in America wooden ones are made on the same principle, at an astonishingly cheap rate. Combmaking is now carried on in every large town in England and on the Continent. The increase in the supply of the raw material may be illustrated in the imports into Liverpool, which average annually 1,300 tons of the horns of stags, oxen, and buffaloes.

SECTION VIII.—THE HATMAKER.

In the Modern Period the hat has assumed an importance which it never before possessed. Its style and use were made indications of office, rank, and good breeding. The Spanish grandees evinced their pride by standing covered in the presence of royalty. Doctors, cardinals, bishops, officers, and princes were all distinguished by their hats. Black, as the universal colour, did not prevail until the sixteenth century; and through all the mutations of fashion a general resemblance to the loose broad brims of the Middle Ages was maintained until the Thirty Years' War—1618-1648.

Hats, like all other articles of dress, underwent a great change in the reign of Louis XIV. The three-cornered cocked hat was developed from the broad brim by folding the brim over to the body of the hat in a triangular form. This fashion soon spread; it was not only adopted in Europe, but even reached America. It was modified to suit the changes in perukes, and when pigtails and hair-powder superseded the bagwig, the two-cornered hat came into existence. Curious as seem the pictures of battles being fought in pigtails, yet in all the armies of the eighteenth century this was the *costume de rigueur*. The French wore the points before and behind, the Germans right and left. This old order of things received its final blow in France at the Revolution, when the cocked hat was hated as symbolical of the past. It was retained in Germany, and was the covering of every Prussian soldier in the battles of Jena and Austerlitz.

The hats as now worn, with high cylindrical bodies and curved brims, originated in the revolutionary period. Apparently adding to the height, they were devised, we read, to give importance to the wearer; and this style soon became the accepted fashion of rich or poor. The advantages presented are counterbalanced by lack of comeliness, and by

the discomfort of hardness and stiffness. Various substitutes have competed with it for public favour, but with very inconsiderable effect. In some the brims form a broad shade from the sun, and seem to recall in their aspect the hats of our ancestors. In the army, cocked hats were superseded by the military cap, and this again by helmets, a modified form of the head-gear of the knights of the Middle Ages. Further changes have taken place in the head-coverings of soldiers of different States, the design being to combine lightness with strength. The hats of the English grenadiers are constructed of bear-skins, on a framework of willow. The highest officers still wear the old-fashioned cocked hat and plumes.

Hatmaking in the nineteenth century has, like all other handicrafts connected with dress, advanced exceedingly in value and importance. Materials formerly used have been increased in supply, and new ones have been added to the number. Felt was long the only substance employed: it was formed mainly from wool or camels' hair; the finer kinds from the fur of the hare or rabbit, while those of the beaver and otter were in requisition for the most expensive sorts. New materials were first obtained from the fur of the musk-rat or musquash, and from the coajo or coypu, a South American animal, the body or foundation of the hat being still formed of the hair of the rabbit. Numerous other substances have been employed, such as the wool of the vecuña or llama, the fur of the rabbit, and that of the mole. From the vegetable kingdom contributions were likewise received of bark, wood, cork, and rushes, together with the down of thistles, mallow, and the cotton-grass. Above all, silk was applied, and eventually brought about a revolution in material and price. The silk is furnished with a long down or nap, fabricated like velvet, with a bright and beautiful surface. The durability of hats thus made is so great as to cause them to be in general request. Improvements were effected in ventilation without

adding to the cost of production. By the use of aquafortis to the fur the surface was corroded and weakened, and made capable of better felting. Advances in *bowing* have also been introduced, by which the plate or fur of the beaver is more easily prepared to lay upon the body. This *plating* or *gilding* of hats—a term borrowed from another handicraft—is a beautiful process, by which a layer of beaver-fur is applied to the felt body. By the action of oxide of copper, or verdigris, an intense black has been imparted, and more successful modes of waterproofing have been invented.*

There are in Paris twenty-five manufactories, employing 1,500 operatives, and the national industry is estimated at the annual value of £1,000,000. The English trade is of greater extent, if not of equal excellence, finding employment for 60,000 workpeople, and producing 500,000 dozens of hats yearly, of the value of £3,000,000. It is one of the oldest of the staple manufactures, and its prosperity has increased since the removal of all fiscal burdens upon both the raw materials and the manufactured articles. Many hats are fabricated in Germany, though not enough for the home consumption, and large numbers are imported from England, France, and Belgium.

The making of straw hats and bonnets is now an important division of labour. The best are still made in Italy, but every country in Europe is engaged in the industry. In England it furnishes the subsistence of from 50,000 to 70,000 people, whilst the annual produce approaches £1,000,000 sterling in value. Straw for plaiting has recently been supplemented in England and Germany, to an extent reaching commercial importance, by the rended leaves of palms.

* For an account of hatmaking and of the manufactories of Messrs. Christy, see the *Penny Magazine*, 1841, vol. x., G. Sup.—"Useful Arts and Manufactures," Society for Promoting Christian Knowledge, &c.

CHAPTER IV.

ARTS RELATING TO METALS AND THE SUPPLY OF FUEL.

SECTION I.—THE MINER.

MINING in England had been pursued with more or less energy since the fourteenth century, but in the reign of Henry VIII., and especially of Elizabeth, a fresh impetus was given to the art by the introduction of a number of Germans, whose methods of work were far superior to those followed in this country. Till then mines had been very limited in depth: thus Agricola, in his "De Re Metallica," written in the year 1550, describes a pit as being for the most part two paces long, two-thirds of a pace broad, and thirty paces deep.

At first the removal of water was performed by buckets, and the ore was lifted in kibbles by an ordinary windlass; but as the depth of the workings increased, the horse-whim was used. The rag and chain pump was first employed in the drainage of Cornish mines. The next improvement was the common lifting-pump, which raised the water by separate lifts of about thirty feet each; the lowermost one supplies a cistern from which the pump directly above it draws, and this in like manner feeds the pump situated in the next lift. By this arrangement each pump has a comparatively small weight of water to raise, less strain is produced, and the effect of leakage is not so injurious. This mode of pumping, though long considered perfect, was found ultimately to be troublesome and inconvenient, as it filled the shaft with rods.

The advantages derived by mining from the application of steam as a motive power are incalculable. It has especially

enabled us to work deep mines, which otherwise could not have been wrought with profit. The first steam-engine employed to drain mines was made by Newcomen, early in the eighteenth century, and quickly superseded every other mechanical appliance for the purpose. With the increased facilities for additional speed thus supplied, corresponding improvements were made in the construction of the pumps, which, together, resulted in the present Cornish engine. This is a single-acting machine, the steam only affecting the piston during its down-stroke, whilst the weight of the pump-rods, &c., acts on the opposite end of the beam, and draws the piston up. One disadvantage of this engine when working a single-lifting pump is that power is wasted in raising the pump-rods.

Wooden pumps were shortly replaced by iron ones, which, although cheaper and less liable to corrosion, are, nevertheless, inferior to those made of brass or gun-metal. The pump-rods are made either of copper, iron, or of wood. In the plunger pumps they are usually of wood, since wrought-iron rods would be in a state of compression, and hence liable to spring; cast-iron ones, it is true, have been tried, but not with the same success as wood, taking into consideration the relative strength, lightness, and durability of the two materials.

Mining has not prominently advanced since it received the aid of steam-power, and there are even now many processes which might be carried on by better methods. Some of the large Cornish, Saxon, and Californian mines, however, which represent the most successful mining operations of the present day, are marvels of engineering skill. An amended method of underground working recently introduced is that called "stopping," by means of which much dead labour producing no return is obviated. It consists in working the lode from behind towards the shaft; the rubbish and refuse of the vein being packed in the excavations. The timberings are removed as the work advances,

being no longer required to support the sides of the lode, which may then collapse.

In the early days of mining, air had to be forced into the workings by machines; and even now the ventilation of mines is not performed so successfully as could be wished. Experience teaches that in a small level the air and powder-smoke lie stagnant, while in a large one a constant motion may be obtained and kept up. The effects produced on the health of labourers from working in badly ventilated mines are obvious; and the prevalence of consumption among the poorer classes of Cornwall is attributed in a great measure to the impurity of the air they breathe.

Another thing most injurious to the health of the miners is the great physical exhaustion consequent on the constant mounting by ladders. "In coming from the bottom of Tresavean Mine to the surface, a depth of 350 fathoms, one hour and a quarter was formerly expended upon the ladders, nearly all of them perpendicular."*

In the majority of mines at present, labourers are brought out by the aid of slides and man-engines: from an early period colliers have been drawn up by the same means as those used for raising the coal, but not so other miners. The most obvious cause for this difference lies in the fact that the shafts of collieries are generally vertical, whilst those of metallic mines are often inclined at various and also at variable angles. The use of the skip or any similar contrivance becomes, therefore, highly dangerous. The original notion of the present form of man-engine, or *fahrkunst*, was conceived in 1833, by Herr Dörell, at Zellerfeld; and the first was placed in the same year in the Spiegelthal shaft, 110 fathoms deep. This engine consists of two wooden rods, moving longitudinally, and furnished with platforms from which the miner passed alternately in his ascent or descent. But at Fowey Consols, in 1851, a new

* "Guide to the Museum of Practical Geology."

system was adopted, consisting of a single movable rod furnished with platforms twelve feet apart, while a series of "sollars" at equal distances were fixed in the shaft, on each side of the rod, to correspond with the levels of the platforms at the end of each stroke. Engines on this plan have since been placed in most of the large Cornish mines. The time occupied in ascending from the bottom of the shaft of the Fowey Consols, 280 fathoms, is only twenty-five minutes, whereas previously an hour was occupied in the journey.

Science has aided the miner in the judicious selection of the position of the holes for blasting, and in the adoption, as a rule for the several charges, of given weights adapted to the lines of least resistance.

Formerly the charge was fired by laying a train of gunpowder, but in 1831 Beckford's Patent Safety Fuse was invented, an improvement so valuable that it is now very generally employed in most mining countries. This fuse, which burns at the rate of from two to three feet per minute, is efficiently protected, even under water, and affords every security against accidents.

Voltaic electricity has been employed to fire charges of powder, but a distinct apparatus is required. It was successfully applied (1843) to the removal of the Round Down Cliff, at Dover, for the works of the South-Eastern Railway. Three charges were fired at the same instant, and the quantity of rock removed from the inclined face of the cliff was estimated at more than 400,000 cubic yards, averaging 380 feet in height by 80 feet in thickness, and 360 feet in length of face. This operation saved about £7,000 to the company.

The remarkable compound, nitro-glycerine, has been recently employed as an explosive agent in mines. Its chief advantages are that it requires a smaller hole than gunpowder, and renders the *tamping* of holes unnecessary. It is cheaper than gunpowder, and suffers no injury from

water. It will, therefore, explode in liquid, yet it possesses certain properties which make it somewhat unsuitable. It gives off a poisonous gas; it is liable to explode by concussion, or by being heated above 300° Fahrenheit, and, if impure, will often explode spontaneously. Still it has been prepared so that it can be safely transported, for if sufficient pyroligneous acid be added to effect dissolution, in that state it will not explode. The oil may be precipitated from the solution by the simple addition of water.

SECTION II.—THE COLLIER.

In the fifteenth century coal-mining became very general, and from that time the quantity of coal raised has continued to increase. In 1655 we find 320 keels, and in 1699 1,400, employed on the Tyne. Newcastle had then two-thirds of the coal trade of the country, and has ever since kept the lead. Taxes of two shillings and soon three shillings a chaldron were imposed for the purpose of building St. Paul's Cathedral; and after the Great Fire of London there was a further charge on coal brought into the Thames, for the erection of fifty new churches. Soon after this we find the trade for the supply of iron-smelters beginning to grow, though it is said that coal was thus first used on a small scale in the year 1619 in Staffordshire; but it was not till 1740 that it was extensively employed.

We are indebted to Campbell for our statistics in respect of this period. The quantity raised in 1670 was 200,000 chaldrons, in 1690 upwards of 300,000 chaldrons, and in 1760 600,000 chaldrons were raised annually. A century ago the collier conducted his operations in the most wasteful manner, not caring how much of the material was lost, provided that the portion saved was got at a low rate.

Great as our coal resources undoubtedly are, yet they are limited in many parts to very moderate depths. We have seen that the commencement of coal-mining took place

where the coal-seams were rendered visible by denudation, and in positions which enabled the adventurers to avail themselves of surface levels, and to drain the mines by adits undercutting the coal strata. But these means were only available to a comparatively small extent, and hence the succession of improvements which have led to deeper mining.

At the commencement of this century, the British yield of coal reached 10,000,000 tons annually. Reliable Government information collected since 1854 shows the steady growth of the trade. Indeed, in no branch of our national industry has more real progress been accomplished.

The present age has witnessed the introduction of many improvements in ventilation, also the substitution of the safety-lamp for the steel mill. Still, mining is increasing in difficulty and danger, owing to the greater depth at which coals have to be worked.

Respiration, the combustion of lights, the deflagration of gunpowder, and the spontaneous escape of certain gases, such as carbonic acid gas and carburetted hydrogen, all combine to vitiate the atmosphere in mines. It is, therefore, imperative to replace the impure air by currents of fresh air. The most simple, ancient, and practically efficient method is placing, contiguous to the bottom of the upcast shaft, a furnace, which, being kept constantly heated, rarifies the air and produces a current. In very early times an air-pipe or channel was built at the side of the shaft, and kept heated to prevent "reversing." Experience, however, showed that the fire was more efficient when applied to the shaft itself. It was an objection to this method, that when the returned air was charged with inflammable gases to a dangerous amount, explosions at the mouth of the furnace frequently took place. This risk is now removed by supplying the furnace with air from above. From early times water has also been applied to ventilation. Upon the downcast shaft a stream is allowed to flow, which, even in small quantities, produces a very fair current of air. It may be

advantageously employed when there is an excess of pumping power, or where the water, after performing its work, can escape by an adit level.

Air-pumps have been applied to the ventilation of mines. The first so used was erected in 1830, near Mons, in Belgium. Mr. Buddle employed a double-acting air-pump at Hepburn Colliery when the accumulation of fire-damp rendered the use of a furnace dangerous. The cylinder was 8 feet by 5 square, the piston making 30 strokes, 6 feet long, per minute, and thereby extracting 5,000 cubic feet of air. This pump was, nevertheless, an inefficient substitute for a furnace. Machines with pistons of 11 feet 6 inches in diameter have since been used at Liége.

The duck machine of Cornwall and of the Hartz is the type of the hydraulic air-pumps improved by John Taylor, in 1810. An instrument of a superior class has been for many years ventilating the Marihaies Colliery, near Seraing. Two tubs, or aërometers, each 11 feet 6 inches in diameter, are suspended to a beam allowing a 5 feet stroke, and 11,500 cubic feet of air are drawn up per minute. An excellent ventilating machine by Mr. Struve has been adopted in many collieries in South Wales. It consists of two aërometers, which balance each other, and move vertically, with side valves, in order to reduce the enormous loss of power by large valve area. By this machine each aërometer is both removing air from and discharging air into the mine. The objection to this, as, indeed, to all other methods of ventilation, except that of the furnace, is its liability to get into disorder.

Other ventilating contrivances are used under special circumstances. That by means of high-pressure steam was proposed by Mr. Gurney, in 1835, and is effected by blowing off steam through a number of small holes placed in branch pipes in an upcast shaft. It may be employed with great safety and effect in the early workings of a fiery seam, or in re-opening old workings. The fan-blast, a relic of

ancient times, is sometimes employed in Belgium and Scotland to force a current of air into the mine, or to ventilate single places. The principle of the Archimedean screw was applied by Motte, in 1840, to the ventilation of mines. The most approved pneumatic machine, however, is Fabry's, invented in 1845, and now much used in the Belgian collieries. The pneumatic method originally adopted was to force the whole of the air through the passages or galleries, all communication being prevented, except in one direction, by means of brattices, stoppings, and doors. The shaft, if there was only one, was bratticed from top to bottom, one section for the in-current and the other for the outflow of air. This method, although simple, was, nevertheless, both inefficient and unequal, the progress of the air being very slow, and the risk of danger proportionately great. If the air was foul anywhere, the whole of it was carried through the rest of the workings.*

Mechanical Appliances for Raising Coal and Water.— During the infancy of the art of coal-mining, the produce was carried by women, not only through the interior of the mine, but also to the surface, either along inclined planes, or by perpendicular shafts with circular stairs. The hand-windlass, or "jack-roll," was the first instrument employed for drawing up the material; and the horse-gin was the next machine adopted for drawing from a depth of fifty or sixty fathoms.

In 1676 the drainage of the collieries of Lumley, Heaton, and Jesmonds was effected by chain-pumps, worked by water-wheels. The earliest recorded use of a steam-engine for mining purposes was at the colliery of Griff, near Coventry, about the year 1700. Hodgson, in his "History

* A simple and effective machine for forcing or exhausting air was patented in June, 1870, by Mr. Edward Finch, of the Bridge Works, Chepstow. The patentee states that with an air-propeller of 12 feet in diameter he "can draw in or expel, at will, 500,000 cubic feet of air per minute, provided there be no obstruction to ingress or egress."

of Northumberland," states that one was erected at Byker, in 1714. After this engines became general throughout the northern district, and led, in the eighteenth century, to the working of numerous collieries which had previously been deemed inaccessible. The introduction of Newcomen's engine brought water-wheels into use. Mr. Smeaton introduced the single-bucket wheel, and by cog-gear reversed the motion without changing the course of revolution of the water-wheel. Finally, the steam-engine, by means of a crank-axle, was made to work the rope-roll direct, much advantage being gained by the introduction of the counterbalance weight. The Newcomen engine was quickly followed by the improved engines of Trevithick, Boulton, Watt, and Wolf, the objects of which were to dispense with the pressure of the atmosphere, and to work entirely by steam. This latter modification led to the erection of engines under ground, and in 1776 one was placed eighty fathoms deep at Whitehaven.

The collier who procures the coal has no concern with its transport to the shaft, that operation being performed by the "putter," who places the coal in tubs, or "corves," and either conveys it to the shaft, or to the nearest roadway.

The trouble and waste of time incurred in transferring the coals from the sledge to the tubs or baskets, led to the adoption of the tram with wooden wheels. On the introduction of horses and ponies to draw the sledges, plank barrow-ways were abolished, and the trams were fitted with broad wheels. The preceding methods, however, fell into disuse during the last century. In all the most important mining districts, the wooden way has been superseded by Mr. Curr's cast-iron tramways.

The details of coal-mining would form an endless variety, but its leading principles may be grouped under two heads :—(1) The *Pillar* and *Stall.*' This plan, adopted in the North of England, comprises the removal of a certain portion of the coal, the remainder being left in pillars,

either to be permanently lost, or to be at some future period partially or wholly removed. (2.) *The Long Wall*, which is the most economical method, comprises the extraction of all the available coal, either by removing it from the shaft outwards, or by driving headways to the boundary, on the rise of the coal, and by working back towards the shaft.

Coal-cutting Machines.—Machines, originally invented by Waring, in 1851, have contributed largely to economy of labour, to an increase in the quantity of coal obtained, and to the improvement of its market price. By their aid gunpowder is dispensed with, and the atmosphere of the mine is kept purer. When cut by machines, the coal is not only larger, but more conveniently shaped for storing, a circumstance which effects a considerable saving in freight. The machines cut horizontal, vertical, and inclined grooves. The results of experiments recently made at the Usworth Pit, near Newcastle, with Mr. Bidder's machine, were eminently satisfactory. Twenty-five tons of coal were cut in the remarkably short space of thirty-five minutes.

The invention of the flat rope, and the Boulton and Watt double-power engine, with a scientific arrangement of the fly-wheel, have also brought about a great revolution in the coal trade. Another invention of late years, the wire rope, has afforded great advantages, on account of its lightness and strength, both for drawing-engines, and inclined planes.

Where coals have to be conveyed in large quantities from a lower to a higher level, steam-engines are the most economical motive-power that can be employed. The best kind of engine for underground transport of coal is, undoubtedly, the horizontal direct-acting cylinder engine, a specimen of which, of 120 horse-power, is in use in the Sedghill Colliery, Northumberland. The substitution of machinery for horse and manual labour is one of the most important points involved in mining economy, and a proper consideration of this subject will, no doubt, result in considerable additions to colliery profits.

Safety-Lamps.—The principle involved in the construction of the Davy-lamps is that gas in a state of combustion will not pass through fine apertures. If a flame surrounded by a cylinder of wire-gauze (the original Davy) be introduced into an explosive mixture of fire-damp and atmospheric air, the gas passes freely through the wire gauze to the flame, and explodes. The flame of the explosion, however, cannot pass outside.

Much controversy has arisen amongst claimants for the honour of this invention; Dr. Clanny's, Sir H. Davy's, and George Stephenson's lamps being those of the earliest date. The invention of Sir H. Davy, announced in 1815, is the prototype of all modern safety-lamps. Since 1816 Davy's lamp has been exclusively employed in the most dangerous situations. The advantage in a pecuniary point of view is considerable, as great extents of wastes were lying under the influence of "creeps," whereby the pillars constituting two-thirds or three-quarters of the entire mine were more or less enveloped in explosive gases. In the opening out of these pillars for successful working, the naked candle could not be used, and the expense attendant upon steel mills was so great that the coal, without some new invention, would have been irrecoverably lost. The original Davy-lamp has been superseded by various improvements, having special reference to power of illumination and security against breakage.

Accidents and their Prevention.

Numerous dangers surround the collier, and it is a duty to use every possible means to diminish the frequency and extent of accidents. In 1812 a conviction of the necessity of Parliamentary interference forced itself upon the public, but it was not till 1850 that Government inspectors were appointed. This interference has greatly aided in the discovery of the principal causes of violent deaths in mines,

and has, at the same time, led to the adoption of many practical suggestions. The great majority of accidents are found to be clearly the results of empirical management or of a want of due precaution, and are therefore preventable.

SECTION III.—THE SMELTER.

The Preparation and Treatment of Gold Ores.

Hydraulic Mining for Gold.—The most simple, and at the same time, most ancient method of obtaining gold is undoubtedly by washing river-sand and alluvium. As now practised by the American Indian, it consists in putting the earth into a wooden vessel, called a *batea*, and stirring it round in water, with a certain dexterity, so as not to allow more water to enter than is sufficient for each turn of the *batea*. By degrees, the water separates and removes the earth, while the gold, being the heavier, remains at the bottom.

Among the earlier of the recent miners in California and Australia the "cradle" was much used for washing auriferous earths. The cradle, like the *batea*, is a mere mechanical contrivance for the separation of the heavy particles of auriferous matter from the lighter and valueless material. The next arrangement which came into general use among Californian miners was the "long Tom." The "Tom" has the advantage over the cradle of getting through a much larger amount of work in a given time, but requires more water. It is now customary, whenever a sufficient force can be obtained, to direct a stream against the dirt intended for removal.

Stamping and Crushing Gold Ores, and Amalgamation of Gold.—When gold occurs in veins, associated with other metals, it becomes necessary to reduce the matrix to a state of fine division before the gold can be extracted; this is usually performed by means of mercury, hence the method

of amalgamation employed for the separation of this metal. The ancients were well acquainted with the property which mercury possesses of combining to form an alloy or amalgam. They took advantage of this knowledge for removing gold from old apparel, first burning the clothes to ashes in an earthen pot. Before the discovery of America, the Germans employed mercury to attract gold from sand, as well as from iron and copper, and in America the usual method of separating gold from the ore was by mercury.

Very elaborate mechanical contrivances are now in use in California, Australia, and other mining countries, for the reduction of auriferous ores and the attraction of the metal, together with others as simple as those described by Diodorus Siculus, quoted in a previous page. The methods introduced by the Spaniards have continued down to the present day. The *arrastre*, which is much employed in Mexico and Central America, consists of a movable vertical axis, provided with cross arms, to which are attached two or more heavy stones. Mules are harnessed to one of the projecting arms, and a rotatory motion given to the shaft. Water-power is also used to drive the stones, which, being set in motion, are dragged over a well-paved bed, and thus, by an action somewhat resembling that of the common muller and slab, the ore is gradually reduced. Mercury and water are added to the ores operated on, and the resulting amalgam is from time to time passed to the retort. The mercury is then driven off, whilst the spongeous gold remaining is melted in crucibles and run into ingots. In Chili the *trapiche* is much used; it is only a grinding-mill, like the ordinary edge-runner. The roller runs on a ground bed-stone, in which a certain quantity of mercury is placed; by the continual trituration of the runner, the ore is reduced and amalgamation effected.

The introduction of mills, first for dry, afterwards for wet stamping, was a great advance upon the ancient mode of pounding ore in mortars. This invention probably dates

back to the beginning of the sixteenth century. The old stamping-mill for crushing tin-stone is the prototype of the Californian quartz-mill, for the reduction and treatment of gold ores. The motive force is either water or steam, and in the construction of the mechanical appliances for crushing the ore and cleansing and amalgamating the gold, modern art and science have contributed their utmost to the perfection of a most efficient machine. By it ores which were previously valueless are made to yield profitable returns, and whilst in the Mexican *arrastre* thirty to sixty per cent. of gold and mercury was lost, in a first-class mill ninety to ninety-five per cent. of gold is extracted.

The Plattner method of gold extraction, used at Reichenstein, in Silesia, for the treatment of residues of arsenical gold, containing about one and a quarter ounces of gold per ton, makes use of chlorine gas. The chloride of gold produced by this means is washed out with water, the free chlorine neutralised with ammonia, and the gold precipitated by sulphuretted hydrogen. After these processes it is reduced by heat, and the finely-divided gold is afterwards united by cupellation with lead.

Tin-smelting.

The operations of washing stream-tin and auriferous sands, of separating oxide of tin from its matrix and gold from its ores, are in many respects analogous. The old Cornish stamping-mill has been improved in its working parts, but remains the same in principle. The smelting of tin is a simple undertaking; it is now conducted either in reverberatory or blast furnaces. Coal has taken the place of turf, and a small quantity of either slacked lime or fluor-spar, which serves as a flux for the silicious impurities, is united with it previously to its being placed in the furnace and smelted.

The mixture of wolfram or tungsten with tin-stone in the

ore greatly interferes with the commercial value of certain deposits in Cornwall, from the extreme difficulty of separating the two minerals; indeed, only a very partial separation can be effected by the most careful picking, in consequence of the specific gravity of both minerals being nearly the same. In 1847 Oxland patented a process, which consists in adding sulphate of soda and coal-slack to the "tin witts," *i.e.*, the dressed ore from the stamps, and heating the mixture to redness. When this is completed, tungstate of soda is formed, the manganese and iron are separated, and the tinstone remains undecomposed.

Two qualities of tin are produced by the smelter, a superior one, used in the manufacture of the best tin plates, and an inferior. The causes of the difference are still unknown, and a method has yet to be devised for converting tin of inferior into tin of superior quality.

Lead-smelting.

In ancient times the ores of lead were smelted in very rude furnaces, or "boles," acted upon by the wind, and placed on the summits of the highest hills. More recently these furnaces were replaced by blast-hearths, resembling smiths' forges, but, of course, larger, and were blown by strong bellows, moved by men or by water-wheels. The principal operation of smelting is at present always conducted in Derbyshire in reverberatory furnaces, introduced there from Wales about the year 1747, and at Alston Moor, in burners similar to those known in France by the name of "Scotch furnaces."

In the old methods of lead-smelting, the loss of metal by volatilisation is considerable, amounting actually to ten per cent. or more. Accordingly, flues of great length, sometimes exceeding a mile, are constructed, in order to effect completely the condensation of the fumes. Other contrivances, with the same object, have been devised; the

fumes have been made to pass through water, by means of powerful exhausting pumps, or water has been projected in a finely divided state into chambers through which the smoke has been made to circulate. Other methods have been tried with greater or less success, but all attended with no inconsiderable outlay.

Desilverisation of Lead.—In 1671 it was considered a remarkable thing that the Dutch should find it profitable to separate silver from lead when one ton of the latter contained three pounds of the former. Now, by Pattinson's process, the silver may be profitably separated if the lead contains only three ounces to the ton. The value of this discovery to Britain is about £60,000 per annum. The process consists in keeping the alloy at the lowest fusible temperature, when solid masses of pure lead are gradually formed and removed. The fluid portion which finally remains is exceedingly rich in silver.

Copper-smelting.

From the writings of Plot (1686) it is clear that copper-smelting was then carried on in blast-furnaces in Staffordshire. Dr. Leigh, who wrote about the same time, describes the processes of running copper in the North by reducing the ore to powder, and afterwards by roasting it till the sulphur was sublimated. In 1765 copper-smelting in Yorkshire was effected in reverberatory furnaces. Carew, in his "Survey of Cornwall," writes that copper-ore was "shipped to be smelted in Wales," either to save cost in fuel or to conceal the profit made by the miners.

At the present time nearly all the copper ore raised in the United Kingdom is sent to Swansea and its neighbourhood and there smelted. The copper-smelting processes are the calcination and melting of the ore, roasting, refining, and toughening. It is remarkable that the quality of the copper produced, not only in different smelting-houses, but in the

same works at different times, has been found to vary very perceptibly. These variations are not indicated by the appearances of the metal, but are manifested in the different processes of manufacture to which the copper is subjected. The smelter cannot yet overcome this defect, because the causes of the variation are at present undetermined.

Silver-smelting.

During the sixteenth century mercury was applied to the separation of silver from its ores, a method still extant, though much modified. Acazete, in his "Voyage to Peru," describes the process of refining in small furnaces and by quicksilver. The latter process, known as the "Patio" method, was discovered by Medina, of Pachaca, in Mexico, in 1557. Knowing that mercury had the property of combining with silver to form an amalgam, and being aware, also, that a hydrous sulphate of copper when immersed in water gives out heat, Medina conceived that if these were mixed with silver-ore and common salt—which was thought to cleanse the silver previous to its combining with mercury —the heat caused by the sulphate of copper would favour amalgamation. The effect of the salt was to convert the sulphide of silver into the chloride; and the ultimate effect of the "magistral" was to heat the mass, and to revive the silver by depriving it of its chlorine.

From this "Patio" method has sprung all others, and although Medina's process has undergone many alterations, the principle remains the same. In 1586 Corsode Leca, a Peruvian miner, added small pieces of metallic iron to effect a saving of mercury, by reducing the chloride of silver. The next improvement was by Barba, in 1590, and consisted in amalgamating in large copper pans heated from below. By this method a great saving of mercury was effected, but the chloride of silver was reduced at the expense of the copper pans. It answered well for the native chlorides, but not for

sulphides. In 1784 Barba's process of reducing silver ores was introduced into Europe by Bern, an Austrian mining officer, and from it has sprung the barrel amalgamation of Freiberg, proposed by Gellert. Salt and crushed ores are mixed and roasted in a reverberatory furnace, by which the sulphurets are converted into chlorides. Small pieces of wrought iron, with the reduced ores and water, are put into revolving barrels; and the iron reduces the silver compound to the metallic state, which is amalgamated in the barrels by mercury. The Veatch process differs from the last, in the employment of tubes instead of barrels, and in the use of steam directly in the pasty mixture of the reduced ores. Vertical plates of iron or copper for removing the silver-ore are fastened to the muller-arms, so as to revolve edgeways through the mass. Other processes are known, but they differ only in the kind of chemicals employed, and depend for the most part upon the composition and character of the ores. One is based on the solubility of chloride of silver in a hot concentrated solution of common salt, another on the solubility of sulphate of silver in hot water, &c. &c.

The method of extracting silver from its ores practised at Konigsberg, in Norway, is exceedingly simple, and consists in melting the cleansed ore with about its own weight of lead, the silver being separated from the resulting alloy by cupellation on a large scale.

IRON-SMELTING.

The gradual decrease of the forests under the demands of the blast-furnaces led to the passing of a stringent Act in 1584, forbidding the further erection of iron-works in the Weald, except under certain limitations. In 1619 Dudley produced both pig and wrought iron with coal in Worcestershire; but his scheme of smelting with mineral fuel was frustrated by the opposition of the charcoal-masters. A

similar trial was made in Hainault, by Octavius Strada, in 1625, who obtained a monopoly of the invention for twenty-five years; it led, however, to no practical results.

It was not till 1735 that the use of coal in the smelting of cast iron from the ore was successfully established. Abraham Darby, of Colebrook Dale, was the first to use coke in the blast-furnace, an improvement which spread rapidly into all other iron-producing districts, situated on or near the Coal Measures. In 1796 the wood-charcoal process was almost entirely abandoned, and the returns of the iron trade gave 121 blast-furnaces, furnishing 124,879 tons of iron. The last furnace in the Weald of Sussex, at Ashburnham, was abandoned in 1829, and there are now only two or three charcoal-furnaces left in the whole of the United Kingdom. With the substitution of pit-coal for charcoal, the manufacture of iron underwent a very important revolution in Great Britain, and the sites of the furnaces were, in consequence, changed to the coal-fields. The change diminished the cost of reduction, and furnished a softer iron, fit for new purposes in the arts. From this era iron-works have assumed a vast importance in our national industry, and many ingenious and powerful machines have been invented for fashioning the metal into bars of every form with incredible economy and expedition. The next great invention which marks an epoch in the industrial history of iron we owe to Cort, who, in 1784, succeeded in converting cast iron into bar-iron, by exposing it on the hearth of a reverberatory furnace to the flame of pit-coal, a process of puddling which has almost superseded all older methods of producing malleable iron. When this process was first used, the annual produce of British iron had been only 60,000 tons, but in the ensuing twenty years it augmented to 250,000 tons. The next great economic revolution which especially distinguishes the modern iron manufacture is the supplying of hot instead of cold air to the blast-furnaces. This discovery is due to Neilson,

and was first put into practice in 1828. It has increased the productive power of the blast-furnace, whilst diminishing the consumption of fuel. Aubertat, in 1811, patented a method by which the gases generated were employed as fuel for heating steel furnaces. In 1832, at Wasseralfingen, in Bavaria, they were also directed to heating the blast. No attempt, however, to burn them was made in England until the year 1845. At present the furnaces of Cleveland and half of those in Wales thus utilise the gases, but the plan is nearly ignored in South Staffordshire and in Scotland.

The principal modification of the mechanical appliances of the blast-furnace is the transformation of the blowing-engines. Formerly the old Watt type of low-pressure engine was the only one in use; at present high-pressure engines are generally employed.

Within the last fifteen years the chief inventions and improvements have been in steel manufactures, many new processes having been introduced. Prominent among them is that named after its inventor, Bessemer, which has already been the means of providing a valuable material, useful in railway and other engineering works, in place of wrought iron. Bessemer's process is one of the simplest methods of producing cast steel in large quantities; it combines in its action that of the ordinary and the puddling steel-melting furnaces, and it substitutes mechanical for manual labour. Fundamentally, the process consists in injecting air into the molten cast iron through a large number of small orifices, in order that the combustion of the carbon and other matters in combination may take place rapidly and uniformly. The process is not adapted for making soft, malleable iron, but, with certain modifications, is capable of producing steel of good quality, composition, and hardness. The varieties of cast iron best adapted for conversion into Bessemer steel are from hæmatite, or from magnetic ores. The finest English pig-iron is from Cumberland hæmatite.

The problem of making steel from the ordinary pig-iron still remains unsolved. Particular varieties of iron are required for the production of peculiar qualities in steel; but at present we are ignorant of the differences between them. Although the mere smelting, as compared with other metallurgical operations, is a simple process, yet, after the introduction of the proper admixture of ores, flux, and fuel, the only satisfactory indication of the working of the furnace is presented by the character of the slag. The quality of the metal produced, apparently under the same conditions, also varies from time to time. Indeed, in one and the same tapping several distinct varieties will oftentimes appear.

SECTION IV.—THE COACHSMITH, &c.

With the rapid growth of wealth and luxury in the sixteenth and seventeenth centuries, the number, variety, and gorgeousness of vehicles increased in every European capital, and Berlin, Vienna, and Bohemia gave their names to the fashions which they severally favoured. The Duke of Buckingham, in 1619, drove a coach and six, which the Earl of Northumberland eclipsed by harnessing eight horses to his equipage. By the year 1680, when the first *fiacre*, or hackney-coach, was started to ply for hire from the Hôtel Fiacre, in Paris, there had appeared phætons, drags or sporting coaches, one-horse vehicles, called cabriolets or cabs, and droskies.

Riding in wheeled conveyances was obstructed by the badness of the highways. No contrivance could make locomotion luxurious over rough roads. Strength was the main thing aimed at by the coachbuilders, in order that their vehicles might endure the hard usage to which they were of necessity subjected. To this condition, taste in design, lightness of construction, and comfort were necessarily subservient. Although the postal system was now general in Europe, the roads remained comparatively few and bad.

Louis XIV. was the first monarch who seriously undertook to remedy these defects, yet he did not accomplish much, and, until the close of the eighteenth century, vehicles, however lavishly adorned, continued to be cumbrous and inelegant. The Emperor Napoleon studied road-making as a means of conquest and dominion, and, by the magnitude of his works, gave an impulse to a movement which has gained strength, and has covered Europe with a ramification of highways of a character finer than the world has ever seen before.

Mr. Macadam was rewarded by the British Parliament with a grant of £10,000 for an invention. His system involves a good deal of destruction to vehicles and inhumanity to horses, from which they are only yet partially relieved by the employment of heavy steam-rollers to level the roads. The direct effects of superior means of communication have been to create a better class of vehicles, to multiply their number, and to give an unparalleled incentive to traffic. Strength, speed, lightness, and beauty of design are now combined in the products of the coach-builder's skill.

These improved modes of locomotion are but introductory to steam transit by means of railways. The United Kingdom is reticulated with 15,000 miles of railroads, over which trains have occasionally run at the rate of more than a mile a minute. America, in parts, is equally well supplied with railways, and yet the system may be said to be in its infancy. What its future development may be it is difficult to foresee. A rapidity of transit has been gained to have prognosticated which half a century ago would have been regarded as folly. The furnishing of the saloon carriages is in a style of princely luxury, more resembling the taste and comfort of a palatial apartment than the appointments for rapid travelling.

SECTION V.—THE LOCKSMITH.

During the seventeenth and eighteenth centuries, the chief masters of the art of lock-making were Germans, who have left works calculated to stimulate the genius and the ambition of young mechanicians. Beauty, simplicity, and security were successfully combined in the form and decoration of keys, and in the cutting of the wards. Indeed, examples are extant which no recent workmanship has yet surpassed. The same handicrafts still engage the skill of many German operatives. In France, the district of Eu, in Normandy, is inhabited almost solely by locksmiths, whose work is famed throughout Europe. England, however, during the last hundred years, has borne away the palm in this branch of mechanism; Bramah's locks were patented in 1784, and obtained a world-wide celebrity, which was subsequently shared by Chubb's locks. These safety-locks maintain the prestige of English work in respect of utility and cheapness, whilst some of them vie with, if they do not rival, the curious taste and beautiful workmanship in which foreign artificers have been hitherto superior. Wolverhampton, where Messrs. Bramah and Messrs. Chubb both have factories, is the most noted place in England for the manufacture of these locks and keys.

At the time of the Great Exhibition in 1851, America put in a claim to a first-class position in this branch of industry, the history of which is narrated in the subjoined extract from the "Report on Iron and General Hardware in the Irish Industrial Exhibition of 1853."

"The fact of one of Chubbs' locks being picked by Mr. Hobbs, in 1851, created no small sensation, inasmuch as it was supposed that the mechanism of their locks was so perfect that it was beyond human ingenuity to open them without the proper keys. The length of time during which the trial was carried on, and the peculiar circumstances connected with it, show that, properly considered, the safety

conferred by these locks was not thereby sensibly affected. The jurors appointed to report on this department in 1851 expressed a doubt whether the circumstance that a lock has been picked under conditions which ordinarily could scarcely, if at all, be obtained, can be assumed as a test of its insecurity.

"On the contrary, we maintain that the feeling of security should be materially increased by the experiment in question. The really valuable construction of these locks was thereby established, while the facilities enjoyed by Mr. Hobbs, not to talk of the skill which he displayed, were such as no one could by possibility enjoy, making the attempt for improper purposes. Among the curiosities which Messrs. Chubb prepared for the late Exhibition was a suite of ten locks of different sizes, including one for a large safe, one street-door lock, a latch lock, and small locks for carpet-bags, trunk, box, and desk, all opened by a gold master-key set in a ring, to be worn on the finger so as to elude observation. Each of the locks is furnished with a separate key, but of these keys none will open any lock but that to which it belongs

"Mr. Hobbs, who was long afterwards recognised as the American picklock, exhibited his own locks, the keys to which were composed of movable parts. These keys, by slight variations, produced, it was said, several hundred perplexing securities, by which any attempts at picking might be frustrated. At a subsequent meeting of the Society of Arts, where Mr. Hobbs had lectured upon the merits of his art, and especially upon his own inventions, Mr. Chubb introduced one of his own workmen, a young man, who in a few minutes picked one of Mr. Hobbs's most perfect specimens with impunity."

SECTION VI.—THE CUTLER OR EDGE-TOOL MAKER.

The progress of the cutler's art during the Modern Period has been great. Soon after the introduction of firearms, a short dagger or bayonet was fixed to the muzzle of the

musket. In no long time this weapon became the most formidable arm in martial use, completely displacing the heavy sword of former days. The great armies of modern times have created an immense demand for steel weapons, and given the utmost vitality to all the iron handicrafts, especially to that of the cutler.

For many years England had imported iron and steel goods. The imports, however, had been restricted by Elizabeth, in order that home manufactures might be fostered. There was a gild of London cutlers in the time of Henry V., but the more important corporation in Sheffield was not legalised until 1624. During the next century the progress of scientific invention benefited the iron and steel manufactures. The production of cast steel furthered the common use of knives and many other cutting instruments, besides rendering them cheaper, better, and more abundant. Improved methods of smelting, casting, forging, rolling, drawing, sharpening, polishing, damascening, and gilding raised the cutler's art to a high state of perfection. Great as was the progress of this art in the eighteenth century, it has been far outstripped in the nineteenth. Shear steel began to be made at Sheffield in 1800. The inventions of Mushat and Lucas, in 1800 and 1804, further extended the manufacture. Forks and scissors were made by rolling in 1805. From this time immense cutlery-works sprang up in England, France, and Germany, and the competition between the three countries has been highly beneficial, for while England stands undoubtedly foremost, yet both France and Germany possess their own peculiar excellences.

Amongst the imports connected with cutlery, there is in Sheffield an annual consumption of more than seventy tons of ivory for the handles of knives and forks, and about 3,000 operatives are employed in forging and grinding the blades. An equal number of workpeople are engaged on pen and pocket-knives, made annually to the value of above £100,000. Very many are occupied in fabricating razors and scissors.

The Great Exhibition of 1851, and subsequent exhibitions both in England and elsewhere, have afforded opportunities to the Sheffield cutlers of proving their matchless skill in domestic and other branches of cutlery. Swords, perfect masterpieces of artistic design, were displayed, their blades damascened, or decorated with elaborate etchings and gilding upon a ground of blue.

French cutlery is chiefly fabricated at St. Etienne and Thiers, where many hands are employed. Table cutlery is here produced at a rate almost incredibly cheap. Germany, despite the superior natural advantages of England, exports knives and edged tools to a considerable amount. Solingen has received the appellation of the Sheffield of Germany, and has, since the Middle Ages, been celebrated for its cutlery, being especially famous for its swords, the blades of which sometimes sell for £100. In Austria, scythes, sickles, and table-knives are made annually by millions, at an exceedingly small cost of production. It is computed that 80,000 Bavarian grindstones are consumed annually in the preparation of these implements.

With the rapid development of the mechanical arts, the manufacture of tools has correspondingly grown. At one time England possessed a monopoly, and the English trade-mark was a guarantee of quality throughout the world. The efforts of European States, however, have been rewarded with a share in the manufacture, while the demand for cheaper tools has extended the British trade, and yet allowed a considerable portion to fall to foreign cutlers. Operatives in wood-work—as carpenters, joiners, builders, turners, and cabinet-makers—employ a great variety of cutting-tools; sculptors, modellers, and pattern-makers require steel tools of many kinds, and all these branches of industry and art have much increased. The demand, therefore, for planes, augers, chisels, saws, and gravers is continually increasing. In some instances the French and Germans have outstripped the English. English planes, however, are as yet unequalled.

Paris, on the other hand, since the period when Dubois and Dupuytren advanced practical surgery to the high scientific position it now holds, has prepared the finest surgical instruments, particularly for dentistry. The most perfect steel-work has now been enlisted in the service of science; and delicate balances and other philosophical apparatus have contributed to the investigations made by our chemists and astronomers.

SECTION VII.—THE ARMOURER.

Among the many discoveries which marked the dawn of modern history, and indicated the awakening of the human mind from its lethargy, that of gunpowder was one of the most prominent, both in its immediate and in its more remote effects. Gunpowder was employed in war, and revolutionised military tactics in the fourteenth century; its utility for rock-blasting had been already tested.

Edward III. is said to have employed artillery at Crécy and at the siege of Calais, 1346 and 1347, as did also the Venetians in a sea-fight against the Genoese in 1377. Gun-metal, a modification of bell-metal, is an alloy of copper and tin. Cannon-founders sprang, not from the armourers, but from the craft of bell-founders. In like manner the manufacture of guns or small-arms was a subdivision of the smith's art. Cannon derives its name from *canna*, "a reed," and in the first instance balls of stone were projected. Mohammed II. is said by Gibbon to have fired, at the siege of Adrianople, in 1453, stone balls weighing 600 lbs. The first large guns were forged, not cast. The latter method, however, was so plainly suggested by bell-foundry that it soon superseded the forge. Cannons were first made of brass in 1535, but no essential alteration took place in the mode of manufacture until the invention of the vertical and, subsequently, of the horizontal boring machines. By the employment of these tools, the founders were able to cast solid cannon, and

drill a bore of any calibre. This method, first adopted at Berne, in 1710, was vastly improved when steam was used as a motive power. In England, at the present time, the largest guns of iron and cast steel are bored and rifled with the nicest precision.

The ingenuity of man has been exemplified in nothing more completely than in devising implements of war. Guns have been invented, under the varied names of cannon, mortars, howitzers, petards, mitrailleuses, &c. They have been constructed of gun-metal, brass, iron, and of steel, wrought under the hammer and cast, of every weight up to thirty-five tons. Cast-iron shot took the place of stone; hollow shot, called bombs or grenades, according to their size, soon followed, with more deadly effect. Still more deadly are grape-shot, cartridge, or shrapnell; and rockets would surpass even shells in their murderous effects. As recently as the Battle of Waterloo, troops were out of range at 800 yards, and even within that distance there was, according to a common saying, "more room to miss than to hit." Now, however, an English Armstrong gun can strike a mark at five miles, whilst the guns of other eminent makers have pierced or smashed a "*Warrior* target" of fifteen-inch iron, strengthened with bolts and oak. Such artillery makes war costly and deadly, and rulers are compelled to reflect before entering upon its grave responsibilities. As soon as we can make the annihilation of an army the penalty of aggressive war, society will perhaps find that heroism can exist apart from slaughter.

Fortification became a new science with the adoption of artillery, and Europe was in the course of time covered with fortresses. France, especially under the direction of Vauban, the great modern teacher of the art, made every important town seemingly impregnable. The enormous power of recently made guns deprived these strongholds of their invincible character, and fortification, as an art, is once more in a transition state. The changes necessitated in the

construction of war-ships is still greater. Vessels clad in armour-plates of great weight and thickness are now replacing the "wooden walls" of England and other naval powers; their armaments consist of a few guns of great calibre, in lieu of the broadsides of the old men-of-war.

Together with the art of casting large guns, there grew up the allied manufacture of portable firearms. These were not, however, in frequent use until a century later than cannon, and even then were so clumsy and heavy that a rest had to be used while the match was being applied.

The musket was for a long while unwieldly; it took a considerable time to load and discharge, and sorely encumbered the soldier, who had to carry two sorts of powder, coarse for loading and fine for priming, to draw the strings of a leather bag to get at his bullets, and to hold, meanwhile, in his hand his musket-rest and burning match. When his piece was discharged, he had to defend himself with his sword. It was thus for a considerable time a dubious improvement over the English long-bow. The match-lock was eventually improved into the fire-lock, or flint-lock. The latter weapon was lighter, and, though it often missed fire, could be charged much more rapidly. The modern percussion cap, invented by Forsyth, of Birmingham, in 1807, still further increased the rapidity of firing.

A musket invented in 1827, by Dreyse, and converted into a breech-loader in 1836, was adopted by the Prussian Government, and startled Europe by its rapid discharge in the late Danish and Austrian wars. Ignition is effected by the pressure of a fine steel wire through the cartridge, hence the designation, "needle-gun." It is unaffected by temperature or vicissitudes of weather, can be rapidly and conveniently charged, and in excellence was far in advance of any other arm in Europe. Now, however, the needle-gun has been equalled, if not surpassed, by the Snider, Martini-Henry, Chassepot, Remington, and other rifles.

Explosive compounds have been investigated by chemists,

with the view to improve or supersede gunpowder. The fruits of these inquiries are a better knowledge of the nature of explosive materials. The introduction of conical bullets has also extended the range. There is now no State in Europe unsupplied with these improvements, in one or the other form. The manufacture is generally carried on by Governments, but such is the enormous demand for weapons, that private manufacturers enjoy a very profitable and extensive business. Birmingham and Liége surpass all other towns in the magnitude of their operations. Paris is distinguished for the elaborate decoration of its arms. Many German cities are busily engaged in the fabrication of guns, whilst the arsenals of Europe contain sufficient stores to arm the world.

SECTION VIII.—MINOR ARTS CONNECTED WITH THE SMITH'S ART.

The advances in the minor arts connected with those of the smith are numerous. The beautiful process of damascening steel, and of producing the brightest hues of the rainbow on iron surfaces, have been brought to perfection. A pound of iron, of merely nominal value, can now, after many elaborate operations, be converted into the hair or pendulum springs of watches, and be worth hundreds of pounds. The methods of tempering steel are so exact that one side of a thin iron plate is occasionally made softer than the other. Iron wire is drawn out to a diameter of $\frac{1}{116}$th of an inch. Sheets of iron are rolled out as thin as tissue paper, or into armour-plates, 20 feet by 4 feet, and 15 inches thick, weighing over 21 tons.* The steam-hammer, patented by Nasmyth in 1842, has helped to extend the range of malleable iron-work beyond all precedent.

* These are the dimensions of the finest armour-plate. It was rolled in fifteen minutes, at Sir John Brown's Atlas Works, Sheffield, September 6th, 1867.

Cast iron appears to have been first applied to the making of cannon, but was superseded by bronze. Castings were for a long period limited to a few simple contrivances, such as cannon-balls and kitchen utensils. No department of the iron-worker's art affords a more marked contrast between the earlier and later stages of its history than that of the iron-foundry. Parts of machinery are now cast which often weigh many thousands of pounds. Ornamental and artistic work, of the most intricate designs, are produced with all the finish of sculpture; and the most delicate steel jewellery has displaced ornaments in wood or brass, which were formerly worn.

The smith's art received an enormous impulse from the introduction of steam machinery into our textile industries. The manufacture of such machinery grew into an independent art, and the precision requisite in its construction led to a still newer branch of work. Men were now constantly engaged in designing and in making tools, powerful, automatic, simple, and exact. Besides the steam-hammer, methods for planing, punching, sawing, filing, and drilling relieve the operative from the toilsomeness of his vocation, while they render his labour more effective. Many implements, such as chains, screws, and hinges, needles and pins, once the product of wearisome monotony, are now obtained in greater abundance and perfection, and at less than a tithe of their former cost, through the agency of self-acting machines. The manufacture of steel pens and the American invention of sewing-machines have effected great industrial changes. The first gross of three-slit pens was sold in 1820 for £7 4s.; a better sort can now be obtained for sixpence. Above 1,000,000,000 steel pens are annually made in Birmingham alone, consuming 150 tons of steel, and the manufacture steadily increases. The trade in sewing-machines is a large one, both in the United States and in England.

As the knowledge of the manifold adaptations of iron

extended, the subdivisions of the smith's art became more numerous. Besides those handicrafts ministering to the universal wants of society, there arose many important, though less comprehensive industries, comprised under the term whitesmith's work. Several of these industries can be traced back to ancient times, but, as the majority are of recent invention, we have included the whole of them under the Modern Period. We shall only notice the more prominent and important.

Tin-Plate Workers.

The art of plating metal vessels with tin was known before the Christian Era, but the application of the process to thin plates of iron was a German invention of the Middle Ages. The advantage of coating iron with a bright silvery metal, little liable to oxidise, was so obvious that the art spread throughout Europe, and was applied to many objects, such as nails, bits for horses, currycombs, stirrups, spoons, and culinary vessels. Notwithstanding the possession of rich stores of tin, the art of tin-plating was not practised in England earlier than the year 1730, and even then only to a small extent. The mines of Germany, discovered in 1240, completely destroyed our previous monopoly in tin, and German tin-plate work triumphed. Till the beginning of the nineteenth century, Germany also kept possession of the manufacture of the iron plates for tinning. The artificers in this branch of industry were numerous enough to found separate trade corporations in the Erzgebirge and Voigtland as early as 1606. A project for making tin-plate in England, in 1670, when a number of German artificers were invited over from Saxony to establish their art, failed, through native opposition to the introduction of foreign workpeople. About the middle of the eighteenth century, at which time the first tin-plate works were permanently established in Monmouthshire, Colbert

made a vain attempt to introduce the industry into France, but no successful works were founded.

Returning to Germany, we find the tinsmith's art flourishing for several centuries in advance of that of any other country. It received a great impetus when the cost of the production of malleable plates was reduced, by the substitution of the method of rolling in lieu of spreading out under the hammer; and of stamping them at a stroke, when tinned, into any required form, instead of fashioning them by hand. In recent years England has led the van in the art of plating metals with tin, and in fabricating therefrom an innumerable variety of articles. Dish-covers of block-tin are made in the lathe, by a process called "spinning," which gives a true curve and shape without a seam of solder. English plated wares of iron retain their lustre almost as long as the precious metals. Tinned iron has of late been applied in the construction of steam-boilers, of huge gasometers, and even of bridges.

Tinned ware is often subjected to a secondary process of japanning, or lacquering. The colours imparted by japanning are bright and transparent, and are still further heightened by gilding. Notwithstanding our proficiency, however, in this branch of art, the best examples are still brought from China and Japan, whence we have derived both the process and its appellation.

The advancement of the tin-plate worker's art in England is shown by the fact that the produce exported, which in 1847 was valued at less than £500,000 sterling, has now reached about £2,000,000.

PEWTERERS.

All the industries into which tin enters have rapidly expanded in recent times, and the purposes for which it is worked are now so varied that the art has become noteworthy from its scope and general utility. Bismuth is

mixed with the melted tin to increase its fluidity, to add to its silvery whiteness, and to give it a more lasting lustre. Quite recently a mode of lining culinary and other articles with enamel has been invented, not, however, to the superseding of tin, since one of its oxides enters into the composition of the enamel.

A compound of tin and bismuth is employed in stereotype plates, and in the metal moulds for soap, and delicate manufactures. There are many other useful compounds, of which the sonorous bell-metal—made of tin blended with copper—gun-metal, and pewter have already been mentioned. Pewter has the advantage of being harder than either the lead or the tin of which it is composed. In order to effect still greater durability, antimony is added, the product being known as Britannia metal. From it are made innumerable articles, with difficulty to be distinguished from silver when polished, such as coffee and tea-pots, dish-covers, salvers and cups, organ-pipes, refrigerators, &c. The chief seats of the industry are Sheffield and Birmingham, where many thousands of operatives are employed.

Wiredrawers.

The property of ductility possessed by most of the useful metals does not appear to have arrested the attention of those engaged in the industrial arts at a very early date. Wire was made, not by the process of drawing, but by cutting and rounding strips of sheet-metal upon the anvil with the hammer and file. Such wirework could not compare with that produced in modern times by the method of drawing.

In the early centuries of the Christian Era, the custom prevailed of interweaving or embroidering both linen and woollen dresses with gold threads. Silver was not used for such purposes until a later period. Wiredrawing, or the method of reducing the calibre, by forcing the metal through

successively smaller holes in a vertical steel plate, is commonly ascribed to Rudolph of Nürnberg, who realised therefrom a large fortune. The drawing-machine was subsequently rendered automatic, and more work effected, by using water as a moving power. The appellation of wiresmiths was now exchanged for those of wiredrawers and wiremillers, terms which first occur in the local records of Augsburg and of Nürnberg, between 1350 and 1360. Improvements in the machinery for drawing wire continued to be made, and Nürnberg remained the headquarters of the art. Towards the close of the sixteenth century, wire, especially of gold and silver, was drawn fine enough for weaving and for spinning round silken thread. It was soon discovered that flattened wire was more brilliant, and went three times as far for these purposes as round wire. The dates of the successive steps of invention and improvement, and of the spread of the art to other States, are very uncertain, for the wiredrawers kept their craft a secret as long as possible, and, for the sake of profit, concealed every new facility of production. English wire was at first made by hand, but of such inferior character that there was scarcely any demand for it. All wirework of any importance, as well as the instruments of the woolcombers, had to be imported from Germany. Christopher Schutz and Daniel Houghsetter are said to have introduced this art into England in 1565, under the auspices of Queen Elizabeth. Other accounts fix a much later date to the introduction of this industry. It must certainly have been long established in the reign of Charles I., for the king, in a proclamation prohibiting the import of foreign wire, states his reasons to be that many thousands of his subjects had long been employed in this handicraft, that their occupation was taken from them, and that English wire was the best in quality. The first wire-mill was set up, it is believed, at Esher, and the first flatting-mill (1663) at Sheen.

Nearly the whole of the brass wire used in Europe is made in the neighbourhood of Aix-la-Chapelle, where are situated the factories of 100 wiredrawers, consuming in their craft 1,250 tons of brass annually. Such is the exceeding ductility of the metal that a pound avoirdupois can be drawn out to a length of three-quarters of a mile, and both round and angular wire can be produced with equal facility.

During the recent period, wiredrawing has kept pace with other industrial arts.

Machines for Wiredrawing.—No industrial operation is more striking to the eye, and more convincing to the mind of the incalculable superiority of machinery over hand-labour than that of wiredrawing. About the year 1800 wiredrawing machines began to supersede the old bench and pliers of the hand-worker, with what advantage must be judged from the fact that the iron wire passes through the drawing-holes at the rate of 10 feet per second, or 600 feet a minute. From the Forest of Dean, where almost solely, in former years, wiredrawers congregated, the art has spread to the midland and northern counties. An enormous quantity of wire is consumed in the form of combs or cards, used in the textile manufactures, a branch of industry in which Barnsley once took the lead ; but every division of drawing, flatting, and of weaving is now well distributed through the chief manufacturing towns, Birmingham ranking the first. The highest development of the art is exhibited in the manufacture of wire ropes and cables. Twisted cords, as slender and flexible as twine, are now used where elegance, strength, and durability are required, and strong cables have been constructed, which have enabled our scientific mariners to take deeper sea-soundings than before. Still more important is the construction of wire cables for submarine telegraphs, which have already linked together two worlds in instantaneous intercourse, and put more than one "girdle round the earth."

PINMAKERS. NEEDLEMAKERS.

Before the invention of wiredrawing, pins and needles were made by hand, of bone, ivory, and metal, and were costly luxuries. Hair and breast pins, of various sizes and patterns, were used in ancient times; and dress-fastenings, or skewers, were in demand. These pins had ornamental heads, which were generally in one piece with the shank, the points being tapered singly with the file. There was, however, no distinct handicraft engaged in the manufacture. The eyes of the needles were formed by looping the metal round at the head. The value of the art of wiredrawing in the making of needles was so quickly perceived that a needlemakers' association was founded in Nürnberg only ten years later (1370) than that of the wiredrawers. Then, as now, the fabrication of fish-hooks was comprised in the same handicraft. The manufacture of English fish-hooks is computed at one-sixth that of needles. German fish-hooks are also in great repute, and find their way to the Italian and Black Sea fisheries. The first mention of pins in England is in 1483. French pins, made of brass, are stated to have been used by Catherine Howard, the Queen of Henry VIII. The earliest fine needles were called "Spanish needles," a descriptive term, seemingly indicative of their origin. It was a Spanish negro who, according to Stow, "first made needles in England, which he sold in Cheapside." He, however, "would never teach his art to any." This was in Queen Mary's time, and in the succeeding reign of Elizabeth a German, named Growse, practised the method, which was lost at his death, and not recovered for nearly one hundred years. Needles of many varieties, fish-hooks, and hooks and eyes are now annually made in numbers counting by thousands of millions, and their manufacture employs many thousands of men, women, and children, both in England and on the Continent. The German provinces of the Rhine, Westphalia, and Fran-

conia, the kingdom of Bavaria, the cities of Vienna and Aix-la-Chapelle are busily engaged in this branch of industry, and export large numbers of needles to the East and elsewhere. In England needlemaking has become a staple trade. Nearly all the inhabitants of Redditch and the villages adjacent, about 10,000 in number, are engaged in one or other department of this manufacture.

We are indebted to North America, again, for the initiative in needle and pin making by machinery, which was carried out in the United States in 1818, and introduced into England, under Wright's patent, in 1824. An improved machine in England, in 1844, produced more than 2,000 needles an hour, or about three times as many as before. In preparing the wire for pins at Birmingham, hand-labour is still employed, but the heads are put on by machinery.

Thimblemakers.

There is so close a relation between metallic thimbles and needles that the arts of making them must flourish or fail together. Once thimbles of leather shielded the finger, but when the eyes of needles were stamped in the substance of the steel thimbles of a firmer substance were required. Metal thimbles are said to have been found at Herculaneum, but more authentic is the fact that they were made in Nürnberg in the last quarter of the fourteenth century. In a little over a hundred years from the origin of the handicraft there were twenty-four metal thimblemakers in this single city. The art was carried to Holland, whence it reached England about 1695, through a Dutch mechanic, who made, at Islington, thimbles of brass, iron, and steel, with indentations punched in their surfaces, to prevent the needle from slipping. Machinery moved by water was substituted for hand-labour at Aix-la-Chapelle and other parts

of Germany during the eighteenth century, and still more perfect machinery has been devised in recent times for stamping and punching. Besides the seats of manufacture in Germany, Paris and London are largely engaged in the machine-made thimble trade.

WIRE FRINGEMAKERS AND METALLIC LACEMAKERS.

Gold embroidery and fringes are used in Court, military, and official costumes, carriage trappings, cornices and curtains, and in the liveries of servants. At first gold threads were used in massive tassels of the pure metal, and such tassels have been found in the ruins of Herculaneum. It is uncertain when the present more economical art began. The plan now adopted is to have the tassels composed of silk covered with threads of gold. Gold thread of extreme fineness was wrought by the Greeks, who also used it for purposes of dentistry. Various examples of fine wire have come down to us. The handle of the sword of St. Maurice, among the regalia of the German Empire, is bound round with silver thread, proving that this metal was made into fine wire at an early date. All such productions, nevertheless, were fashioned with the hammer. The process of gilding silver wire, followed quickly upon the discovery of wiredrawing, and machines were subsequently invented to spin the wire upon a body of silk thread. Gold lace and fringe makers flourished from this time in the chief cities of the Continent, and in London. Since the peace of 1815, there has been a diminished demand for articles of this nature, arising not only from the smaller number of gold epaulettes and sword tassels required, but also from the general prevalence of a more subdued taste. Enough, however, still remains of this industry to maintain profitable, if not thriving establishments in London, Paris, Vienna, and Berlin.

Nailers.

Nails have been in universal use from very early times. Made of bronze, they have been dug from the classic ruins of Pompeii; and in the Teutonic tongues the word "*nagls*" belongs to the very earliest written remains. Nailers were early recognised as a separate craft, and their forges were to be found in every village at an early date. An article so small in itself, yet so great in its utility, originates in more than one country a manufacture of national importance. William Hutton, in his "History of Birmingham," written 130 years ago, speaks of the prodigious number of nailers along the approaches to that great town. Dudley and its vicinity, in the "Black Country," is the great seat of the trade. There are about 300 different sorts made; there are also, on an average, ten different sizes to each class, giving altogether about 3,000 distinctive names.

Recently, forging by hand has been superseded by the invention of machinery for nailmaking and nailcasting. Cast nails are brittle, and the fact of their brittleness causes them to be in no great repute. Machine-made nails are not in other respects equal to forged nails, and the demand for the latter, in consequence, still continues very large. The injurious effect upon the nailers is not that their orders are smaller, but that the vast supply from machinery and casting has brought down prices to a minimum. The same effect has been felt in Sweden and France. Nailmaking machinery has now been introduced into Germany and Austria. These machines produce from 7,000 to 9,000 nails an hour, while a skilful nailer makes but 1,500 to 2,500 a day, according to the kind. A computation of the number of nails produced by some of the States engaged in this industry will show its magnitude and importance. One pound weight of iron will yield 2,000 nails of an average size. Now, besides the immense numbers used for home consumption, England exports 500

tons, or more than 2,240,000,000 nails. The Belgian exports exceed even this vast quantity, the annual weight being 800 tons.

The Sawmaker.

An ancient Egyptian saw, made of bronze, is amongst the antiquarian treasures of the British Museum; and, from the oldest drawings and descriptions, we may conclude that there was no material difference between modern saws and those in use before the Christian Era. There were saw-mills in Germany in the fourteenth century. Saws of various kinds and sizes are made in several German towns, but England has long held the first place in the manufacture. Sheffield is the great emporium, although London equals it in the production of well-made articles. Fixed saws, compound saws, and circular saws are not yet half a century old, and are amongst the fruits of the application of steam-power to machinery. Fixed frameworks of saws, the blades of which can be set at different distances apart, or displaced and replaced, are now employed to cut a whole trunk or log of timber into planks at a single operation. The beautiful sawing-machines of the Government dockyards, particularly those employed at Portsmouth, were constructed from suggestions of Brunel, the great engineer, and have been copied in every dockyard or extensive private mill. A trunk of rosewood, mahogany, or walnut wood, by these means, is cut so accurately into thin layers or veneers as to be at once ready for French polishing. Flexible or band saws, for curvilinear work, such as staves and felloes, and the more delicate tracings and fretwork ornamenting pianos, act with equal precision.

Circular saws are sometimes of the extraordinary diameter of 9 feet, while others, 4 feet across, and making 1,000 revolutions per minute, perform the work of cutting through plates and bars of iron, an operation formerly accomplished only by the tedious and laborious use of the chisel.

The most prominent improvers and inventors in this department were Cameron, in 1807, Lefevre, in 1817, Philippe, in 1831, and Powis and James, inventors of the band-saw, in 1858.

The Filecutter.

The tool known as a file is mentioned in the Book of Samuel and in Greek mythology. In the ancient forms of the Teutonic also the mention of the name indicates an early acquaintance with the tool. From the smallest mouse-tail file, used in the delicate operations of the watch and philosophical instrument maker, to the square file, for the smith's heaviest work, there is a multifarious diversity in shape, size, and gauge of cutting. The variety is still further extended by the style of cutting. There are rasps, the surfaces of which are dotted over with raised points, driven up by the strokes of a triangular punch; floats, with a single series of parallel cuttings, made by a sharp-edged chisel, and used for filing soft metals; and cross-cut, or files proper, where a second series of ridges or "burs" intersects the first, and covers the surface with the keenest teeth. Dead-smooth files are made by the Swiss, for the work of the watchmaker, and are of so fine a cut that the unaided eye cannot discern the ridges. Burnishing-irons may be classified with files, being employed to give the final polish to steel.

Files are made in various parts of Germany, and fine ones especially in Nürnberg, but England is the great emporium of the trade. The headquarters of the manufacture are Sheffield for the heavier kinds, and Warrington for the finer varieties, known as "Lancashire make." The manufacturing establishments are very large, the most celebrated in Warrington employing between 3,000 and 4,000 workpeople. Hand-made files are produced with an astonishing degree of dexterity, only to be acquired by practice in a minute subdivision of labour. The burs on a file, cut

by a boy with a sharp-edged chisel, at the rate of 150 or 200 a minute, are traced by the sense of touch alone. The lines, nevertheless, are as straight as though ruled by machine. Such skill was long thought to be proof against the aggressions of machinery, the application of which to filecutting would probably have been deferred indefinitely, had it not been for the ignorance and chronic discontent of the filesmiths, with whom strikes for higher wages were very frequent. Employers were eventually compelled to choose between labour-saving machines and the loss of trade. M. Bernot, of Paris, invented a filecutting-machine, one of which was set up in Leeds, in 1859, with great success. One result was a decrease in the cost of production, which almost immediately reduced files to one-eighth of their former price.

Miscellaneous Toolmakers.

It would not be possible to enter into the details of the history of numerous products of the toolsmith's art. Such are the piercing implements of the auger kind, for boring, bradawls, gimlets, hand, ferret, and pulley borers; metal, stone, and wood-borers. Steam boring-machines are now constructed of irresistible force, capable of piercing holes five or six inches in diameter through thick slabs of iron, or drilling with unerring accuracy the still larger bore of steel cannon. The makers of shoemakers' awls were in the last century a distinct and numerous body. Corporations of axe and windlass makers existed in Nürnberg during the sixteenth century.

Weight and Scale Makers.

Although weights and scales, as articles of manufacture, differ from each other sufficiently to warrant their forming distinct branches of industry, yet their relation in use has caused them always to be connected in one trade. Both

weights and scales are often constructed of brass, iron, or the two metals in association; the brass and iron not alloyed or combined. Weighing-machines, large enough for wagons to rest upon, are sunk in the highways, where the amount of toll is decided by weight. Commodities are more than ever sold by weight; railway luggage is weighed by means of a strong iron steelyard. Spring balances are used for many purposes; while, for scientific exactness, especially in chemical experiments, balances are made sensitive to the fraction of a grain.

Chain and Cable Smiths.

Iron chains of different patterns and dimensions have long been in use, but never to so great an extent as in recent times. The position of this craft amongst the iron industries is indicated by the fact that there were twenty-nine master chainmakers in Nürnberg at the commencement of the seventeenth century, and that in 1683 a heavy iron chain was thrown across the Danube, in order to bar the passage of the river. In modern times chain cables have displaced the old hempen ones for the raising and dropping of ships' anchors. Chain or suspension bridges are not uncommon now. The earliest was hung over the river Tees, in 1741. Telford, the engineer, constructed two beautiful specimens across the Conway and the Menai Straits. One of the finest examples ever built was the Hungerford Bridge thrown across the Thames, opened in 1845, and afterwards removed to Clifton, near Bristol. Machinery was first used in the manufacture of chains and cables in 1815, soon after their employment in the English navy had become general. The invention was that of an Englishman, named Brunton. In 1839 a peculiar chain was invented by Wright, of Glasgow. It was constructed of iron wire, twisted into links by a curious manipulation, and then dipped into molten copper, in order

to solidify the coils. The machinery necessary for the twisting of the wires was likewise the device of the inventor of the chain.

A method of casting chains has also been tried. The invention of wire rope, however, has checked the growth of chainmaking, whether by hand or machinery.

BUTTONMAKERS.

Buttons were an early English manufacture, but it was not till the beginning of the seventeenth century that they began to supersede the use of girdles. Stamped at the outset from metal, they were impressed with figures in relief by means of a die. Gradually, not merely all the metals, but other mineral substances were employed, as jet, precious stones, and such artificial productions as glass, enamel, &c., together with shells, pearls, mother-of-pearl, coral, paper, horn, ivory, bone, woven cloths, and embroidered stuffs. Single factories in Birmingham find employment for over 3,000 hands. One factory requires 200 tons of sheet-iron annually, which is transformed into 300,000,000 metal buttons; another factory produces buttons of every kind, to the number of more than 500,000 gross. Buttonmaking is likewise pursued in Germany to a large extent, particularly in Berlin and in Nürnberg. Machinery of the most ingenious description has been employed in every process of the manufacture, and has greatly extended the trade.

EMBOSSERS AND PLATERS.

The art of beating out and embossing thin metals, as practised by the girdler, was applied to decorative metalwork of every kind, such as the chased carvings on censers, lamps, and imitations of the precious metals. Iron goods, with scarcely an addition to their cost, are lacquered to imitate brass, and delicate cast-iron tracery is covered with the thinnest coat of the precious metals, and equals their splendour.

By the electrotype process, most of the inferior metals, without losing their own valuable properties, can be transformed in appearance to gold and silver. Although a recent art, it has quite superseded the deadly process of water-gilding, in which mercury was used. The yearly value of the manufacture is already estimated at upwards of £2,000,000 sterling.

Ironfounders.

The most delicate of designs and the most stupendous masses of iron now proceed from the founders' moulds. Associated with and dependent upon casting is another new handicraft, called modelling. At first the models were made of wax impressed in lime, and afterwards melted out, being thus destroyed for every casting. Now, however, the finest types are of gypsum or clay, skilfully made, while less important ones are of mahogany or deal, and the mould is formed of loamy sand and powdered charcoal. Castings are also made in pieces, afterwards joined together, worked over, varnished, bronzed, plated, or gilded. Amidst the indefinite variety of elegant objects thus formed and manufactured, to imitate rarer and more costly bronzes, or antique work in gold and silver, are statuettes, candelabra, candlesticks, vases, flower-stands, inkstands, tables of elaborate design, chairs, garden seats, lattice-work, doors, sofas, and bedsteads. Many of these articles are of French make, and exhibit the artistic fancy of that people. The first cast-iron bridge was constructed at Ironbridge, on the Severn, about a mile from the famous iron-works of the Colebrook Dale Company. It was built after the plans of Mr. Pritchard. Many bridges both of cast and wrought iron girders have since been constructed; amongst the most remarkable of which are the Southwark, Westminster, and Blackfriars bridges over the Thames, in London. These multifarious applications are owing, not so much to the facility with

which molten metal can be poured into moulds, as to improvements effected in the quality of the metal itself. Germany, France, and Belgium are largely engaged in iron-founding. France is celebrated for its bedsteads of cast iron, many thousands of which reach distant parts. In recent years, gas-fittings and gas cooking-stoves have been introduced. One manufacturer made an apparatus of this nature by which he roasted a whole ox.

In concluding our notice of the ironfounder's art, we must draw attention to one of its latest developments, as described in a note on "Castings in Iron" in the Report of the Irish Industrial Exhibition of 1853:—

"Cast iron is capable of assuming an analogous molecular condition to that of hardened steel, by being cast in iron moulds. The castings thus produced are termed 'chilled iron,' and the degree depends upon the temperature of the liquid iron, its quality, and the thickness of the casting. There is, however, a remarkable difference between chilled iron and fire-hardened steel. By heating the latter to a dull red heat it is again softened; while the chilled castings are removed from the moulds immediately after the metal has set, and are allowed to cool in the air, and, although at a very bright red heat, the chilled part does not get softened. In close connection with this quality of chilled cast iron, it is also worthy of note that perfectly cold moulds do not yield castings as hard as when made black hot. Chilled castings are used for punches for red-hot iron, ploughshares, axletrees, boxes and naves of wheels, cylinders for rolling metal, heavy hammers and anvils, and iron for stamp-heads for crushing ore. Cannon-balls are also examples of chilled iron, being cast in iron moulds—not, however, in order to communicate the quality of chilled iron. Such chilled shot was patented by Captain Palliser in 1863. It equals steel in hardness, and is perfect in form. At Shoeburyness, on the 13th Sept., 1866, a 250-lb. shot of chilled metal, propelled by 43 lbs. of powder, in a 9-inch muzzle-

loading wrought-iron Woolwich rifle gun, was sent through a target of 8-inch rolled iron, 18 inches of teak, and three-quarter inch backing of iron, and reached about 20 feet beyond."

SECTION IX.—THE COPPERSMITH.

The old art of tinning copper utensils, lost since the time of the Romans, has been revived in the Modern Period, and supplemented by the still more beautiful processes of gilding, silvering, and enamelling, all of which give a more cleanly and agreeable aspect, and guard against the poisonous effects of acids upon copper. The process of rolling has also been applied to copper. Copper sheathing for ships has become common; the *Alarm* at Woolwich, in 1761, was the first vessel of the British navy thus defended, in order, as it was stated, "to preserve her from worms in southern climates." In the course of twenty years the success of the experiment was so undoubted, that all the ships of the royal navy were similarly protected.

The compounds of copper with other metals have in recent times become of greater importance and of more varied application than the metal itself. Bronze and gun-metal—compounds in varied proportions of copper and tin, with sometimes a little lead—have been applied to a diversity of purposes, as, for instance, statuettes, inkstands, small ornamental works, chandeliers, fountains, vases, lamps, and clocks, not to speak of statues of splendid workmanship and noble dimensions. The bronze statue of Louis XIV., erected in 1699 in the Place Vendôme, and destroyed by the revolutionary mob in 1792, was one of the largest equestrian figures ever cast, weighing 60,000 lbs. Bronze-work in Paris employs many thousand hands, and is valued at more than £1,000,000 sterling annually.

Most telescopic reflectors, made of an alloy similar to that used by the ancients for their mirrors, consist of two

parts of copper to one of tin. Tombac is an alloy with large quantities of zinc, and has the appearance of gold; whilst pinchbeck, prince's metal, and ormolu are modified alloys of a similar nature. Brass, an alloy of copper with zinc, is of such universal utility that, after iron, no metal, either simple or compound, is applied to so many purposes. Since the manufacture of German silver has become commercially important, the metallurgy of nickel has been undertaken upon a considerable scale. The best samples of German silver are composed of copper eight parts, nickel three, and zinc three and a half. The several white metals bearing different names are only varieties of this compound. Argentine is used as a substitute for silver, and a multiplicity of articles once made of the precious metals are now formed of this cheap and elegant substitute. The manufacture is chiefly carried on in Sheffield, Birmingham, and Vienna. Nickel, is found associated with copper, and its separation is troublesome. From being worthless and vexatious to the miner, it has become by this new application of its properties a metal of high value. Since its employment, the old method of plating copper with silver by means of rolling until the two were firmly united, has been wholly discontinued. British plated work of every kind is now more extensively carried on than before. Its annual value is estimated at £1,500,000 sterling, Birmingham alone using over £50,000 worth of the precious metals for the different processes.

Our history of copper-working would not be complete without reference to coining. Brass and copper coins were in use amongst the ancients. Lead was circulated in England until 1620, when its employment was superseded by the appearance of the first large copper coinage. Halfpence and farthings were issued in 1665. The copper pennies of George III. weighed one ounce. The present bronze coinage, issued in 1860, is composed of 95 per cent. of copper, 4 of tin, and 1 of zinc. 44 pennies weigh 1 lb.

SECTION X.—THE BRAZIER AND BELLFOUNDER.

No industry has received greater benefit from the advance of metallurgy than that of the founding and working of brass. The extreme malleability of brass is one of its most valuable qualities. Like copper, it spreads out under the hammer into thin sheets, and is suitable for many useful objects. The manufacture of sheet brass by the hammer was formerly a very profitable handicraft, but this process has since been superseded by rolling. So flourishing was the brazier's art in Germany up to the end of the seventeenth century, that even England imported German brass goods. There was no English foundry until 1702, when the first was erected near Bristol. There are now, however, many important works in Birmingham and in the manufacturing towns of the North. Both in the drawing and rolling of brass, the metal requires frequent annealing, in consequence of its susceptibility to become hard and brittle under pressure.

The making of brass tubing is another branch of braziery. Sheets of brass are cut into strips under revolving discs of steel; the edges of these strips are curved over a mandril or axis, whilst the joint is soldered in an oven. A new and cheaper method has been invented of casting brass and iron bedsteads, with brazen ornaments attached. The process formerly adopted was the somewhat fatiguing and cumbrous one of having two distinct castings, one for the bedsteads, and one for the ornamentation.

Ormolu—a species of brass, an excellent imitation of the red gold of the French—is in great use in France, Germany, and England, for the manufacture of ornamental timepieces, gas-fittings, and decorative work.

As we have seen, the alloys with copper are very numerous, and though sometimes they are all colloquially called brass, yet they are distinct both in nature and use. Such are bronze, bell, and gun metal. Tin enters into their com-

position, its presence making the compound harder; while to it is due the fluidity of molten bell-metal, and its sonorous property when solidified. The intermixture of a little lead, on the other hand, makes a soft metal, which yields to every tool, and is much used for cocks or taps.

Brass founding or casting, as a distinct branch of art, was practised with success during the Mediæval Period. Its chief divisions were the casting of statues and of bells, and several of the immortal artists of Italy, as Lombardo, Michael Angelo, Buonarrotti, and Benvenuto Cellini, are identified with the art as much as with painting, sculpture, chasing, and architecture. Italy, however, did not continue to produce such great masters as Angelo and Cellini; and genius and industry declined in that country. Meanwhile, a succession of eminent artists in brass appeared in Germany. Sepulchral monuments of old date and the brass fountains cast in 1789 are enduring masterpieces of German skill.

In the fifteenth and sixteenth centuries bellfounding was a much more difficult undertaking than it is in our own time. We are now able to calculate with almost unerring certainty how the metal will behave in the mould, what the shape of the bell will be, what its precise weight, and what note it will sound. In mediæval times, however, when scientific appliances and investigations were little understood, such works were carried out upon empirical methods. The greater merit is, therefore, due to the founders who, without specific guides, cast some of the largest bells in the world, as those of Erfurt, in 1497; Paris, 1680; Cologne, 1448; Breslau, 1507; Bruges, 1680; Oxford, 1680; Lucerne, 1636; Halberstadt, 1457; Dantzig, 1453; Exeter, 1675; and "Old Tom of Lincoln," 1610. The weights vary from "Old Tom of Lincoln," of $4\frac{1}{2}$ tons, to the bell of Erfurt, weighing nearly 14 tons. The largest in existence is at Moscow, and is stated to weigh 250 tons. It was cast in 1736, but fractured in the following

year. Another bell, of 110 tons, was cast in 1817. The great bell of Vienna, founded in 1711, is the heaviest out of Russia, and is little short of 18 tons. "Big Ben," of Westminster, named after Sir Benjamin Hall, Chief Commissioner of Works, in 1856, weighed nearly 15½ tons; it was 9½ feet in diameter, and 8 feet in height, with a clapper of 12 cwt. "St. Stephen," made of the broken materials of "Big Ben," when this last was found to be cracked, was lighter by almost two tons. The casting of bells is a successful Irish industry, and Irish bells are in demand even in England, and in our distant colonies.

Statuary in brass and its allied compounds, neglected during the seventeenth and eighteenth centuries, has again revived. Bronze memorials in remembrance of eminent men adorn most of the cities of Europe. The most recent and remarkable in London are Landseer's colossal lions, at the base of Nelson's column. Unmixed zinc has proved to be well adapted for casting. Six statues of this metal can be produced at the cost of one of copper or of brass. Statues and other works in zinc come from the mould with every marking as sharply and clearly defined as in brass, and with the advantage that the parts can be cast separately, and afterwards put together. Germany holds the first rank in this department of industrial art, which is carried on in many towns, but in none with so much success as in Berlin and Munich. Even the productions of Paris, the home of tasteful design, do not excel those of these cities, either in the quantity or in the beauty and variety of the castings.

The Chinese are ingenious metallurgists, and their metal mirrors and ornamental productions have long attracted the attention of nations more advanced in civilisation. Their bronzes exhibit great ingenuity in the modes of moulding, and in the adjustment of the mould, which secures as nearly as possible a perfect coating by one operation, without the subsequent use of the tool. The

tom-toms and cymbals of bronze are forged with the hammer; their composition is seventy-eight parts of copper, and twenty-two of tin. This alloy when newly cast is very brittle, but when confined between discs of iron, heated to cherry-redness, and plunged into cold water, is rendered malleable. A gong is usually composed of eighty parts copper and twenty of tin. Many of the Chinese bronze mirrors possess remarkable properties, often alluded to by European writers, but never successfully reproduced by our manufacturers.

SECTION XI.—THE GOLDSMITH, SILVERSMITH, AND JEWELLER.

The Modern Period opens with the discovery of the gold and silver mines of America. The rich treasures that were poured into Spain and Portugal seem to have proved only a fleeting enjoyment for these countries. The German mines, however, yielded richer stores than ever, and the Fuggers of Augsburg are said to have acquired an annual profit of 2,000,000 guilders from the Erzgebirge. The mines of Annaberg, Marienberg, and Freiberg were extremely productive, and it was not unusual to meet with large masses of native silver, especially in Alsace. Scarcely a town of importance in Germany or in Italy was without its fraternity of goldsmiths, from whose studios came some of the richest and choicest works of art.

Germany, nevertheless, began to lose its monopoly with the influx of the precious metals from Mexico and Peru, and the whole of Europe soon shared with princes and the Church the luxury of gold and silver utensils. Pewter and wood were displaced from the tables of all families above the ranks of the industrial classes, and silver became so general that the frequenters of cafés and taverns disdained to drink from tankards of any other metal. In England, which dates its great advance as a commercial country

only from the Modern Period, this expensive practice reached to such lengths that the Government interfered, and prohibited the use of silver plate in public houses. Much came into our country through Spain, in the regular course of trade, much also through the buccaneers. Our coinage was extended and improved, and many new applications were found for these metals. It is calculated that gold of the value of £75,000,000 was coined between the reigns of Elizabeth and George III., whilst an almost equal amount was issued during the long reign of the last-named king. Since the Californian and Australian discoveries, more than £10,000,000 sterling in gold have been sometimes put into circulation in a single year.

Before the modern system of banking was established, the English goldsmiths acted in the capacity of bankers. Child's bank, the oldest now in London, was thus started by a goldsmith in 1663.

The art of the goldsmith has completely changed its character. No longer is he, like Benvenuto Cellini, painter, architect, sculptor, and chaser. Division of labour has been carried out to an extreme degree. Instead of being confined to ecclesiastical works alone, the goldsmith's art has a wide range, and the use of gold for personal ornaments has become almost universal. The properties which give to the metals their great economic value are exhibited by the precious metals in the highest degree, and by so much add to their utility. The capacity for subdivision is so great that their use in gilding and electroplating, by which the resplendency of gold and silver given to commoner substances, is almost as great as in their solid form. At no previous period in the world's history could the yearly produce of the precious metals have been compared with what it has become in recent times. The workers in this industry still rank in the highest departments of handicraft, and if, on the one hand, they receive fewer commissions as artists, and produce works exhibiting less of genius than in

mediæval times, on the other hand all sumptuary restrictions have disappeared, and the demands for less ambitious specimens of elegant workmanship have multiplied exceedingly. The number of goldsmiths and the extent of the business they severally command have both increased. Factories have arisen where formerly only the benches of single artificers were needed; and machinery now lightens the labour of the goldbeater, the wiredrawer, the embosser, and the engraver, and performs processes once so toilsome with a rapidity and perfection which hand-work could never have approached. Articles in gold and silver, cheaper and of finer workmanship, are thus produced, the demand for them is stimulated, and the number of artificers employed is greatly increased.

Jewellers' work has remained connected with that of the gold and silver smith, and has made almost as great progress. The cutting of gems, an art in which the ancients excelled, but which was lost in the Middle Ages, revived in Italy in the fifteenth century. The greatest impetus, however, to the jeweller's art was given by European intercourse with India, whence diamonds were first obtained. Golconda yielded its hidden treasures in 1534, since which time many famous stones, of almost inestimable value, have been found. A fine diamond, weighing more than an ounce and a half, is in the Russian sceptre. The Koh-i-noor, or Mountain of Light, found in the mines of Golconda in 1550, and now in the possession of Queen Victoria, originally weighed 800 carats, but by unskilful cutting was reduced to little more than 102 carats. Diamonds were discovered in Brazil in 1728; one weighing fourteen ounces was sent to the Court of Portugal, its value being variously estimated between £400,000 and £224,000. Another celebrated diamond from Brazil weighed 254 carats, and was designated the "Star of the South." Diamonds are also obtained from Borneo, and have been found in South Africa. Diamond-cutting is a branch of the lapidary's rather than the

jeweller's art, and has been pursued with much success at Amsterdam. Before the mode of cutting the diamond by means of its own powder was practised, the full brilliancy of these jewels, and, consequently, their full value, were unknown. Herman, a Parisian jeweller, cut diamonds by the agency of their own powder early in the fifteenth century. According to Dana, Louis Berquen of Bruges did this as early as 1456; but in China and India the art has been practised from remote antiquity.

Included under jewellery are pastes, pearls, artificial pearls, cameos, coral ornaments, and enamels. The cameos are figures cut in relief upon shells, formed of two or three layers of differently-coloured porcellaneous substances. Their cutting is an ancient art, demanding the highest skill, and producing the most exquisite results. Red coral is principally used for necklaces, and was worn as an ornament in very ancient times.

CHAPTER V.

MACHINERY AND MACHINE CONSTRUCTION.

THE advantages which have been conferred by the steam-engine on science and the industrial arts make the study of this motive power of modern times both interesting and important. Formerly the steam-engine was popularly regarded with distrust. It was injurious, men said, rather than beneficial, to the interests of society; but the facilities which it affords to industrial enterprise fully testify to the benefits which it has conferred on all classes. It is not too much to say that the steam-engine has revolutionised the commerce of the world, and promoted the social, political, and intellectual advancement of the human race more than any other machine ever invented.

History of the Steam-Engine.—The force of steam confined in close vessels was known to the ancients, for the priesthood of Egypt and of Greece employed it for superstitious purposes. Hero (B.C. 120) invented the *æolipile*, and thus produced rotatory motion by the agency of steam. This engine consisted of a hollow globe turning on a vertical axis containing water, with four horizontal tubes, having their exterior orifices bent at right angles. When the water boils steam issues from these orifices, and causes the globe to rotate upon its axis. Though it is now only a pretty philosophical toy, yet not many years since a two horse-power engine constructed on this principle was used in connection with a coal-mine in Northumberland.

Blasco de Garay (A.D. 1543), after an interval of nearly 1,700 years, succeeded in propelling by steam a ship of 200 tons burden, at the rate of three miles per hour. The

apparatus consisted of a boiler, and the power was transmitted through paddle-wheels.

Solomon de Caux (1615), a Frenchman, forced up a jet of water by means of steam, on a small scale, as an experiment.

Giovanni Branca (1629), an Italian, used steam as a motive power for grinding mortar, &c. The machine was worked by a wheel with vanes, upon which jets of steam were projected.

The Marquis of Worcester (1663) generated steam in one vessel, and conveyed it to another for the purpose of lifting water. His invention must be taken as the starting-point of the vast development of steam-power. He erected on the banks of the Thames one of his engines, of about two horse-power, which was employed in supplying London with water.

Sir Samuel Morland (1682) investigated the expansive nature of steam. He calculated that water, when converted into steam, expanded in bulk 2,000 times: the actual expansion is, however, about 1,728 times. He also proposed to raise water by its means.

Dr. Papin (1690) made some contributions to our knowledge of the properties of steam by his experiments with the cylinder and piston, and the invention of the *digester*, in which he dissolved bones and other animal solids by means of the high temperature which water receives under great pressure. He also applied the safety-valve.

Savery (1698) combined the inventions and discoveries of Worcester, Morland, and Papin, and constructed a tolerably effective steam-engine, which was used for raising water from mines. The steam was generated in a boiler, and allowed to pass into a receiver provided with valves and pipes. By alternately condensing the steam and recharging the receiver, the water was drawn and forced up the pipes; and by using a double apparatus, the action on the water

was continuous. In this engine the atmospheric pressure applied to a comparative vacuum raised the water to a height of about twenty-four feet, and the water was forced still higher by the expansive power of the steam. Savery's engine is limited in its application to the raising of water; and there is great loss at each successive lift, occasioned by the steam coming into contact with the cold water in the receiver.

Newcomen (1705) introduced the well-known atmospheric engine, combining Papin's idea of the cylinder and piston, and Savery's method of producing a vacuum by condensation. In it the alternate admission of steam and injection of water was effected by hand, by means of cocks; and it is remarkable that the first considerable improvement made upon Newcomen's engine was due to an ingenious boy, named Potter, who, to save work and gain time to spend in play, attached strings to the cocks or valves, and caused the main beam of the engine to open and shut them in the ascent and descent of the stroke. Beighton availed himself of this clever contrivance, and made the condenser of the engine self-acting, by fixing to the valves gearing worked by plug-rods instead of Potter's strings. Brindley, also, about this time, added an improvement in the "water-feed" for the boiler, which he made self-acting by means of a float in the boiler communicating with a valve in the feed-pipe, and thus he regulated the supply of water.

Smeaton rendered the mechanism of Newcomen's engine so perfect that his own engine on Newcomen's principle became generally adopted.

Watt, while repairing a working model of Smeaton's, in 1765, found that its defect consisted in the cooling down of the cylinder, by the injection of cold water, thus involving a great loss of steam, with a proportionate expenditure of fuel. Hence his inventions for condensing the steam in a separate vessel. He added an air-pump, to improve the vacuum and remove the water. The first engine constructed by Watt was called the "atmospheric engine;" this only

differed in principle from Newcomen's by having the steam condensed in a vessel separate from the cylinder. His next great improvement was to make the engine double-acting, by introducing the steam alternately above and below the piston, so that in the downward stroke the steam aided the atmospheric pressure. This new principle required a rigid connection between the piston-rod and the beam, for in Smeaton's engine, the pressure being only downwards, the connection was made by means of a chain attached to a circular arc at the end of the beam, an arrangement no longer suitable. To ensure the vertical working of the piston, Watt invented his parallel motion, one of the most beautiful contrivances in the whole range of mechanism; and to render the motion of the machinery uniform, a large fly-wheel was employed, turned by a crank by means of a rod attached to the opposite end of the beam of the engine. A plagiarist acquired a patent for this crank, and so prevented Watt from using his own discovery. The great mechanician then substituted for it the "sun and planet wheel," since abandoned for the simpler motion of the crank. He also introduced the "governor," which is self-acting, reduces or increases the supply of steam, and thus regulates the speed of the machinery. Other mechanical contrivances, to render the whole self-acting, were also introduced by him, such as the arrangement for lifting the valves, by which the steam was admitted above and below the piston. Watt also introduced the method of using high-pressure steam expansively, by allowing the steam to enter the cylinder during only a part of the stroke, and to finish the stroke by its expansion, thus usefully expending nearly all its force, instead of wasting it either in the condenser or in the open air.

Since Watt's time various improvements have been made in the steam-engine, among which may be mentioned the "slide-valve," moved by an eccentric wheel attached to the axis of the fly-wheel, to admit the steam to the cylinder, and the tubular boiler. In the history of the steam-

engine, the introduction of the high pressure is of great interest, because all our locomotives are now constructed on that principle, the condenser being abandoned on account of its inconvenience. In this the steam is made to act as in Watt's double-acting condensing engine; but in place of a vacuum being formed by the condenser and air-pump, the steam is blown off into the atmosphere. Subsequently Trevithick discharged the steam into the funnel of the furnace, and so increased the blast, which last contrivance was used by Stephenson without acknowledgment.

MACHINE-MAKING.

Machinery driven by steam is a distinctive feature of the present age. Goods of all kinds are now manufactured with a rapidity, regularity, and finish unattainable by the most skilful and practised firms aforetime. Machinery, clearly, cannot *create* force; its object is to economise force supplied from without, or to turn force to the most productive account. It is the business, therefore, of the machinist to adapt the power to the machine, neither supplying too much, which would be expended wastefully, nor too little, which would be ineffective. A sound first principle in construction is that "the fewer the parts and the simpler their action to effect the result required, the better the machine." Power has to be transmitted or accumulated, that is, increased in effect; it has to be altered in direction, communicated at different points, changed in velocity, and also to be equalised by variable regulators, such as springs, fly-wheels, governor-balls, &c.

As all these considerations involve computations based upon mathematical science, it is not the result of accident that the machinery of modern times did not exist in ancient days; for, until Galileo, Newton, Leibnitz, Descartes, and Euler had reduced mathematics to a system, it was not possible to investigate the laws of mechanics and to found a

science upon them, still less to apply these laws in controlling the forces of nature, and in making them the prime movers of automatic machinery. The invasion of mechanism into what has hitherto appeared the domain of human labour grows more complete every year, and has within the last century given us a new and clearer insight into our place in creation. The apprenticeship of toil and suffering which man has endured for ages, appears, in the light now shed upon the world by mechanical genius, as but a preliminary step to higher conditions of being.

Smooth and easy action is an essential condition of a good machine, and this result can only be realised by simplicity of construction and accurate adjustment of the parts. The quality, strength, and durability of the materials of which the machine is made are likewise elements that affect its utility. Machine-making, therefore, belongs to a high order of mechanical art, and has given rise in turn to the subsidiary art of tool-making, especially tools for planing, slotting, hammering, drilling, and punching.

Some of the noblest industrial establishments in the civilised world are those engaged in the manufacture of machinery. So far are these from depriving artisans of employment, that many reckon their operatives by thousands, as in the royal dockyards of England, in the railway factories, or in the works of many first-class engineers in England, Belgium, France, Germany, and Austria.

Some machines—as, for example, the locomotive—contain within themselves the motive force, which is applied in a direct manner to the work to be performed. Such machines are often called principal ones. There are also auxiliary machines, which are set in operation by the transmission of force or motive power from some fixed centre or prime mover common to the whole system. Such, for instance, are the mules and looms of our cotton-mills, worked from one central steam-engine.

So manifold are the applications of machinery that it

would not be possible, even were it desirable, to enumerate all in detail. We shall simply endeavour to illustrate briefly some of the more prominent operations in the working of metals and wood. Those processes in certain of the industrial arts, which have had distinctive machinery applied to them, are referred to under the chapters to which they severally belong.

Illustrations of some Details of the Machinist's Art.

Machines for Forging Iron, &c. Nasmyth's Hammer.—The steam-hammer was invented by Nasmyth in 1838, and patented in 1842. In this latter year the invention was applied to pile-driving with such success that no great work of the kind has subsequently been executed without its aid. The main feature in the construction of the steam-hammer is the direct manner in which the power of steam is employed to lift up and to let fall the mass of iron which constitutes the "head." The vast range and perfect control over the force of the blows enable the largest or smallest forge-work to be performed by the same hammer; and this machine is now employed wherever the working of malleable iron is extensively carried on. Parts of the most gigantic marine engines, anchors, and Armstrong guns, as well as the most minute details of the military rifle, are executed by it. The weight of these hammers ranges from 100 to 12,000 lbs., and the fall from one foot to six feet. Various modifications of this machine are now in use, such as hammers with concave surfaces, for the forging of cylindrical bars, and sets of hammers in a frame, for small works of various patterns and for nails. Attached is a crushing or pressing apparatus, for the purpose of giving a uniform density to the heated iron, and for ridding it of the oxidised laminæ which cling to its surface.

Machines for Rolling Metal.—Rolling-mills were known in the seventeenth century in England, but were of little

practical use until Cort's improvements were patented in 1784. Now, however, rolling-presses have completely displaced the old process of forging iron plates. Thick bars of iron are flattened out and lengthened by being passed successively between the rollers, the openings of which are graduated for the continuous reduction of the thickness of the plate. All descriptions of bar-iron and rails for railways are rolled in a similar manner, by means of graduated grooves in the rollers. The celerity of the operation is such that in one heat an iron rod can be rolled nine times, extended in length from four to thirty-two feet, and reduced in thickness from an inch to three lines. With rollers slightly tapering in form, thus producing a wedge-shaped space between them, springs for carriages are forged and shaped. By another adaptation of the rollers, iron plates can be bent to their proper curve for boilers and for ship-building. Amongst the multifarious purposes to which rolling-mills are applied are the making of links for chain bridges, tires for the iron wheels of railway carriages, screw-boxes with four or six corners, and curved ironwork of almost every description.

Machines for Manufacturing Tubes.—Leaden tubes for the conveyance of water have been used in England from the thirteenth century. Other metal tubes of forged and riveted plates, or of cast iron, were afterwards not uncommon. They were all, however, made by tedious processes, until the year 1820, when a modification of the wire drawing apparatus was suggested for lead tubing, and the rolling-mill was used for the curved iron plates to be formed into tubes. The principle of the machine is this—a heavy plug of lead, about a yard long, is cast with a perforation of about the same diameter as the tube required. Into this bore a mandril or iron spindle is fitted, after which the lead is pressed and drawn through a series of steel collars, successively smaller, until it is reduced to the size wanted, the calibre of the bore remaining unaltered.

Machines for Cutting Metals.—Cutting-tools are of various kinds. One of the simplest is the large and strong shears, the cutting-blade of which forms the short arm of a lever, and is made to descend and close against the lower blade by the revolution of an eccentric wheel applied to the extremity of the long arm. Another form is that of the circular scissors, one blade of which makes a complete revolution while the other remains fixed.

In like manner vertically-acting tools pierce delicate goldwork into patterns or cut two-inch holes in boiler-plates with equal facility. The teeth of saws are expeditiously formed by these machines, as also chain links, wheels for watches and clocks, plates of steel for the pen manufacture, and blades of knives and scissors. Perhaps, however, their most remarkable performances are in connection with machine-made nails. The iron plates for nailmaking are cut into strips at the cutting-press. These strips are afterwards presented to the nailcutting-machine, sometimes six at a time, according to the number of cutting-punches with which it is fitted. These punches are capable of striking 150 or 160 times every minute, and thus of making six nails of the neatest appearance at every stroke, or nearly 1,000 a minute.

Machines for Drilling and Boring.—There is no division of labour which has benefited more by the introduction of automatic machinery than that of the drilling and boring of metal. Such machines were first used about the year 1820. Iron is now drilled with the greatest ease and nicety to diameters varying from half an inch to six inches. Borings by the cylindrical machine, of cannon, pumps, steam cylinders, and cylindrical blasts, are made of enormous dimensions, and with the greatest accuracy.

Machines for Filing, Planing, and Slotting.—In these machines, which are allied to each other in their mode of action, the metal to be wrought, instead of revolving as in the lathe, is moved backwards and forwards horizontally,

while the chisel acts on its surface, and shaves off a thin or a thick riband of metal, according to the object to be served. In rough work the chisel reverses itself, and cuts again on the alternate backward journey, but in fine work it acts during the forward motion only. The chisel for filing is a mere point, but plays, nevertheless, upon an area of iron sometimes as much as thirty feet by nine, and smoothes the surface with such precision as scarcely to require a subsequent polish. The slotting-machine, similar in principle, is used in smaller work.

Machines for Cutting Screws.—Screws, whether those for common carpentry and smithery, or the larger sort, for presses and engineering works, are usually cut in the lathe. The nick in the head and other requisite contrivances are made by separate operations. M'Cormick's patent machines, recently invented, instead of cutting away the material, form the worm of the screw by compression. The advantage of this method is that it can be used with great facility, and screws can be made more cheaply. Two youths are now able to make 6,000 screws six inches long in the course of a day, the weight of iron amounting to two tons, and the saving of metal compared with old methods being sufficient to cover the cost of manufacture.

Machines for Embossing and Stamping.—Machinery has invaded even the art of the chaser. His beautiful productions, so esteemed in the Middle Ages, are now closely copied, whilst new designs are worked by the aid of stamping and embossing presses. One of the chief applications of these machines is to coining and medalling, an art which extant ancient coins prove to have been understood to some extent long before the Christian Era. Buttons, small ornaments, spoons, forks, and numerous hollow vessels are also formed by stamping. The most perfect machine which has yet been devised is Uhlorn's, which has been in operation only since 1847, and by means of which from thirty to seventy-five coins, according to size, can be struck every

minute. An ingenious modification is applied to gold ring-making, by which not only is the ring struck at one operation, but an inscription or a border is at the same time impressed round the circumference.

Machines for Planing Wood.—A planing-machine for wood was constructed by Bramah in 1802. A less effective one had been in use from 1791. Improvements on these inventions appeared in 1818 and in 1841, the first of which enabled mouldings and grooves to be shaped, while the last extended the powers of the machine even to spiral ornamentation. Irving, in 1843, and Jordan, in Belgium, in 1845, adapted these machines to carving in general, to small work in ivory and the softer stones, as well as to arabesque scrolls and wreaths of wood, both for furniture and house decoration.

Machines for Sawing and Chopping Firewood.—Firewood—an article which, though of humble character, is of universal consumption — has engaged the attention of machinists with the view of economising labour in sawing and chopping it. Pelletier, in Paris (1820), Meyer, in England (1839), and Krug, in Saxony (1848), turned their attention to this industry; wood is now prepared for bundles at the rate of 180,000 pieces an hour. In the manufacture of lucifer matches, machinery on the same principle is very largely employed.

CHAPTER VI.

Arts Relating to Man's Intellectual Nature.

SECTION I.—THE PAPER-MAKER, PRINTER, AND BOOKBINDER.

It has been shown that throughout mediæval times some few of the costly papyrus and parchment rolls of classical antiquity were preserved in the monasteries, their contents being made known to mankind generally only when the art of printing was discovered. From the literature thus preserved libraries filled with books eventually replaced those which had contained only rolls. Cotton paper was introduced into Europe from China about the ninth century, and superseded parchment. Documents of that period on cotton, including diplomas of Italian princes, have been preserved in foreign museums. The first manufactory of cotton paper was established in Spain in the twelfth century, and about the same time in France and Germany; but state documents continued to be written on vellum. Paper made from linen rags is supposed to have originated in Spain, and to have been introduced into England in the fourteenth century. The written leaves or sheets were strung together between two boards, the outside covers being decorated with precious stones and metals. In universities, as well as in cloisters, libraries were very small. Indeed, so rare and costly were some volumes that they were kept fastened or chained up. In the fourteenth century the library of the King of France consisted of only 910 volumes. The method of stitching the leaves together with thread, and of

glueing their backs, was first practised in the beginning of the fifteenth century.

The introduction of paper-making into England did not take place until the sixteenth century. The first made in our country was by John Tate, jun., at his mill in Stevenage, Hertfordshire, and in 1588 another mill was established at Dartford, in Kent, by John Speilman, who was afterwards knighted by Queen Elizabeth. For nearly 200 years after this period, only very common paper, principally for wrapping, was made, and it was not until 1770 that J. Whatman introduced the making of fine paper from the Continent, where he had acquired a knowledge of the art. The first machine for making continuous paper was invented in 1799, by M. Robert, a workman in the employ of M. François Didot, at Enones, in France. To Mr. Bryan Donkin, a workman employed by Mr. Hall, at his establishment at Dartford, is justly due the credit of further perfecting the paper-machine in 1804. Since then such a succession of ingenious improvements have been made by Crompton, Brown, Taylor, Barrett, Ibbotson, Willis, Hollingworth, and other English manufacturers that every variety, both of fine and coarse paper, for writing, printing, and wrapping, is now manufactured with ease and rapidity. Paper more than four miles in length and two yards in width has been produced in one piece. Fine writing paper is sized with gelatine, dried, and cut into sheets at the rate of sixty feet in length and seventy inches in width per minute.

Various wire or water marks, as they are called, were formerly used by the early makers to distinguish the different kinds of paper ; thus, a head with a fool's cap and bells originated the name of the paper called foolscap, and post paper seems to have derived its name from the mark of a horn, which was formerly carried by postmen, and blown to announce their arrival. Paper now rarely bears a trade-mark.

There is in the British Museum a curious book produced by Jacob Christian Schaffer, at Ratisbon, A.D. 1775. It describes the manufacture of paper from different substances, the sixty leaves of the book being composed of as many different kinds of paper. The bark of the willow, beech, aspen, hawthorn, linden, and mulberry; the down of the catkins of the black poplar, and the silky down of the asclepias; the tendrils of the vine, the stalks of nettle, mugwort, and dyer's weed; various other kinds of leaf, fibre, and stalk; as well as straw, reeds, moss, lichens, wood-shavings, sawdust, potatoes, and fir-cones were employed. The paper in all the specimens is of very inferior quality. Many substances have been tried, but nothing has yet been found to answer so well for papermaking as linen, cotton, and hempen rags. Patents have been taken out for an extraordinary variety of substances, but with the exception of straw, esparto or Spanish grass, and (on a very limited scale) the hop bine, no new ones have come into anything like profitable use.

Printing.—The Middle Ages may be said to terminate with the invention of printing, about the middle of the fifteenth century. The art originated in the fabrication of playing cards and manuals of popular devotion; the former were merely pictures consisting of a single page, while the latter formed little books of several pages, each page containing a picture of some saint, with short texts from Scripture. The pages themselves were printed impressions from engravings on blocks of wood. These prints or books as they are called belong to the first half of the fifteenth century.

By the employment of movable types of metal in a matrix or mould, block-printing has been transformed into the printer's art, as it now exists. The first printed books were published by Guttenberg and his companions. Several of these still exist. There are, besides, Letters of Indulgence from Pius II. (A.D. 1454-5), twelve copies of a Psaltery

belonging to 1457, and a Latin Bible—the so-called thirty-two lined—which was commenced in 1450 and completed in 1461.

Printing, at first kept a profound secret, rapidly spread through Europe; like most other successful inventions, it supplied an urgent want. Up to the commencement of the fifteenth century, the followers of trade and industry had no other means of intercommunication than by writing or by travel. Language was as yet ill-formed, in the North and South of Europe. The singing-gilds, poor students, and school-men improved the vernacular tongue; public schools were opened in the industrial towns, partly to prevent the "wandering" of apprentices and journeymen, partly to facilitate intercourse with distant markets; books were thus required, and at length produced. Almost within a generation, the press inaugurated a new era. One of its first-fruits, and one which produced extraordinary effects, was the printing of the ancient Greek and Roman classics. Then came the Reformation, and with it editions of the Holy Scriptures in the vernacular languages. Liberal thoughts were printed and disseminated in thousands of pamphlets, spreading religious and scientific knowledge in every direction.

Before the middle of the sixteenth century great improvements had been made. New type had been invented, and the old rendered more beautiful and uniform, and paper had been improved. Haas, in Basle, discovered a method of putting together systematically the lines of type and the spaces, and the Frenchman, Ambrosius Didot, perfected the *stege* (printer's furniture) which was at first cast out of the metallic types. In 1550, Danner, of Nürnberg, introduced the brass spindle into the printing-press, which, in 1620, was still further improved by Wilhelm Jansen Bloen, of Amsterdam. From this period, the primitive machine with its wooden frame, screw-spindle, and turning-lever, remained without alteration, until the beginning of the

present century, when it was superseded by the Stanhope, Columbian, and Albion presses. Improved apparatus now rapidly succeeded each other, such as the prop, the knee-lever, and the cylindrical press, all of which have at last given way to the printing-machine. This was a German invention, by König, of Eisleben, in Saxony (1803—1810); though machine-printing was first suggested by Nicholson, in 1790. König and his partner, Bauer, of Stuttgard, afterwards manufactured these presses, and in 1806 had so perfected them, as to be able to print sheets of paper on both sides, at the rate of 800 to 1,000 per hour. The *Times* was first printed by steam, in 1814, from König's machine, which struck off the sheets at the rate of 1,800 an hour. This was, however, subsequently raised to 4,000, 15,000, and 20,000, by the improvements of Cowper, Applegath, and Hoe, an American. The printing-office of our London *Times* is a gigantic establishment, the daily edition being reckoned from 50,000 to 60,000 copies. So rapidly is this paper printed that speeches delivered in the House of Commons up to nearly four o'clock in the morning have been found at the principal railway stations by six o'clock. In an article headed "Metropolitan Journalistic Enterprise" (*Printer's Register*, April 6th, 1871), it is stated that a leading evening paper, the *Echo*, having the largest London circulation, has produced its several editions at the rate of 650 impressions per minute, or 39,000 per hour. The machinery is by H. Marinoni, of Paris, and a masterpiece of "skilled labour applied to production."

Common work, such as handbills and cards, is still done by the hand-press.

Types were first cast in England by Caxton, in 1720. Brand, a Dane, constructed a type-founding machine, which cast 4,000 pieces in an hour. Casting by hand was superseded in the United States, about 1840, by the invention of machinery, and thus the production of type was more than trebled. Machine typefounding has been carried on with

great success in Germany, especially in Leipzig and Berlin.

Typesetting-machines soon followed. In December, 1842, the types of the *Family Herald* were set up by machinery invented by James Young. In 1862, an improved invention by Hattersley appeared in the Industrial Exhibition at South Kensington. In the same year Hart's machine was exhibited before the British Association at Cambridge. Later, that of Mr. C. Felt attracted notice.

Stereotyping was practised early in the eighteenth century, and was carried on by William Ged, of Edinburgh, in 1730. It was also in use amongst the Dutch in the last century, but was not in successful operation in London till the year 1804. In the previous year, Didot, of Paris, invented, by means of metallic matrices, a process which preserved as distinctly as in a wood engraving the sharpness and clearness of the original type. The use of a matrix resembling papier-maché externally has since become general.

Printing in colours by means of blocks was practised in the fifteenth century, and improvements were introduced at intervals up to the year 1836, when Baxter's beautiful plan of oil-colouring was first successfully carried out. Chromo-lithography, or colour-printing by machinery, has been, since the year 1851, brought to high perfection by Mr. G. C. Leighton.

In consequence of this extraordinary mechanical progress, the business of the printer has become very important, spreading everywhere, and in some places attaining truly gigantic proportions. Every town of importance in Europe and America now possesses printing-offices and bookselling establishments. In the German book trade, there are 147 booksellers and 30 printing-offices, with about 38 steam and 164 hand presses. The largest establishment, the Brockhaus, sent a collection of 356 works to the Exhibition of 1851, for which a prize medal was awarded. Near 5,000,000 book-

sellers' parcels are annually transmitted from Leipzig, the amount realised by their sale being estimated at £2,250,000 sterling. The French State offices, established in 1640, possess 414 specimens of type, weighing more than 700,000 kilogrammes. The State printing-office of the Imperial Court at Vienna, established in 1816, employs over 850 workmen; its type weighs 3,000 cwt., while its punches and matrices are 60,000 in number. It has 525 sorts of type for the native languages, 62 for those of foreign countries, 126 alphabets, and 160,000,000 letters. The work is performed by 40 steam-presses, which annually print 20,000,000 sheets, and 200,000 reams of paper are consumed yearly.

Six thousand new works annually appear in Germany together with about 1,300 newspapers. The British Bible Society has distributed since 1804 nearly 53,000,000 copies of the Scriptures, in 148 languages and dialects; while the Religious Tract Society, since 1795, has sent forth 600,000,000 copies of religious pamphlets and books, in 110 languages.

The art of bookbinding has also improved since its invention by the Nürnbergers. Splendour in binding is a taste which may be traced to very early times. The missals and antiphonals placed in churches exhibited magnificent exteriors, enriched with reliefs in gold, silver, ivory, and precious stones. In modern bookbinding, costliness is no longer carried to this extreme, and there is a want of that solidity and durability so remarkable in older work. Books are so much in demand that labour-saving machinery has been applied to almost every operation in binding. They are now gilt, lettered, embossed, and otherwise ornamented with extraordinary rapidity.

A novel feature in literature is the remarkable success of circulating libraries, such as Mudie's, W. H. Smith's, &c. The public libraries belonging to the several societies and to the State in London, Paris, Vienna, Rome, Berlin, St. Petersburg, and Munich are very extensive, some of them

containing over 800,000 volumes; that of the British Museum probably surpasses all others.

Newspaper and periodical literature is continually extending to meet the growing wants of an increasing population. Illustrated works are richer and more abundant. Photography is giving its aid to engraving. Art and science thus spread their treasures; and, at no distant date, let us hope, everything that is true and beautiful will be brought within the reach of the humblest as well as the highest in society.

SECTION II.—THE CLOCK AND WATCH MAKER.

In 1500, Peter Hele, of Nürnberg, conceived and carried out the idea of bringing portable clocks into general use. He constructed them, in consequence, so small as to admit of being carried about in the pocket. The essential peculiarity in Hele's invention consisted in the substitution of the mainspring for the weight. The case and the dial, with the hour-figures inwrought, were of metal, and, from the fact that they were oval in shape, were called Nürnberg eggs. From this time may also be dated the *fusee*.

These inventions not only led to the making of portable watches, but completely altered the form and principles of time-measurers. During the sixteenth century they were very costly, and could only be purchased by wealthy persons. In the reign of Louis XI. they appeared in France, and in 1577 in England, where they were valued at £54 each. The first seen in Britain was worn by Lady Arabella Stuart.

It was during the same century that small clocks began to be made for household use. The first of which we read came from Florence, in 1518, as a present from Julio di Medici, afterwards Pope Clement VII., to Francis I., of France. In 1544 the corporation of master clockmakers in Paris obtained from the same monarch a charter,

forbidding any one not admitted as a master to manufacture clocks, watches, or alarums. It was about this time, also, that horology was first applied to astronomical purposes. In 1560, Tycho Brahé, the famous Danish astronomer, and the teacher of Kepler, had at Uraniburg (the City of the Heavens) four clocks, which indicated hours, minutes, and seconds. In 1577, Moestlin constructed an instrument which marked 2,528 beats in an hour. By counting the number of strokes during the passage of the sun's disc across the meridian, he determined the sun's diameter to be 34′ 13″. The celebrated clock in the Minster at Strasburg was constructed (1571—1574) by Isaac, Abraham, and Josiah Habrecht, under the supervision of the astronomer Dasypodias.

We come now to the third era, the discovery of the pendulum clock. Galileo was but a boy when he stood watching the swinging of the lamps in the cathedral at Pisa, and noticed that their oscillations were isochronous, *i.e.*, made in equal spaces of time. Many years afterwards he recollected the circumstance, and drew up on paper his notion of a pendulum. No practical application was, however, made of the idea, the working out of which was reserved for Huyghens, who, in 1657, forwarded to the States-General of Holland the description of a clock constructed on this new principle. In 1673 he published his "Horologium Oscillatorium," perhaps the most remarkable mathematical work produced before Newton's "Principia." He therein shows that oscillations, to be isochronous, must be made in the curve called the "cycloid," and describes the mathematical contrivances necessary to compel the pendulum to describe this curve. He also discovered that the pendulum oscillates more slowly as it approaches the equator, from which fact it was deduced that the earth is not perfectly spherical, but an oblate spheroid.

Towards the end of the sixteenth century the use of clocks had become more general. They were no longer

restricted to the ancestral halls of the nobility, but were a common ornament in every-day rooms. In 1658 spring pocket-watches, such as are *now* in use, were invented by Hooke, an Englishman. Eighteen years after this, at Amsterdam, the first "repeater" was made, a watch that struck the hours by the compression of a spring. Repeaters are manufactured capable of striking the quarters also, and others, called "minute repeaters," are even made to record the minutes. The chief use of these is to ascertain the time in the dark.

The anchor escapement was an invention of Clement, a London clockmaker, in 1680. The contrivance has for its object the conversion of the circular motion of the wheels into the vibratory one of the pendulum. In 1715, Graham introduced his dead-beat escapement—an improvement on the last-named—together with his celebrated mercurial or compensation pendulum, for rectifying the irregularity in the oscillations caused by the expansion and contraction of metallic substances with changes in the temperature.

From the days of Graham until now the science of horology has received no further development of any great importance, although numerous improvements have been introduced in every mechanical portion of the art.* Successive developments have resulted in the production of the modern astronomical clock, which comprises all the most refined means of adjusting isochronous mechanism to the measurement of very small intervals of time.

Turret or church clocks differ from the other timepieces in the large size of their machinery, in the arrangements of their parts, and in the circumstance that hammers placed upon large bells are made to strike the hours, and sometimes the quarters. The machinery of chimes very nearly resembles

* One of the latest of these, by Mr. Dalgety, is a peculiar mode of suspending a clock pendulum, and maintaining it in action with a minimum of friction.

that of a musical box, levers connected with the hammers which strike the bells being substituted for the springs, which in the box are caused to vibrate by the projecting pins of the revolving barrel. The motive power of a turret clock is supplied by the descent of a heavy weight, which is regulated in its downward movement by the oscillations of a large pendulum.

Turret clocks are now frequently illuminated, so as to show the time at night, an improvement introduced within the last few years. For this purpose the dial-plate is usually made of semi-opaque glass, and jets of gas are placed behind. The Exchange clock at Leicester is lit by placing two large lenses before the gas burners, the illumination being thus evenly diffused over the surface without glare. The clock at the Horse Guards is visible at night by means of light reflected from a gas-burner hidden behind a parapet.

The electric time-ball, a modern invention, is a contrivance for showing the exact time once a day. This machine, as at Greenwich, is a large ball made of wickerwork, with a covering on the outside. At a little before one o'clock the ball is wound by hand to the top of the staff, and at the exact hour a current of electricity is communicated from the clock in the Observatory which loosens a trigger, and allows the ball to drop. There is similar apparatus at private establishments in Cornhill and Cheapside, also at the electric telegraph station in the Strand; one on the Nelson Column, Calton Hill, Edinburgh, visible from the harbour at Leith; and one at Deal, to enable ship-masters to compare their chronometers with Greenwich time.

A large number of clocks and watches are now made in Germany and in the French Jura. In the districts of Baden, Freiberg, and Neustadt, the centres of the German clock and watch trade, there are 1,200 masters and 5,000 hands solely occupied in this branch of manufacture. The number of clocks annually made is about 500,000, of the value of £1,500,000. About 600 beech trunks, 1,175

cwt. of copper, 475 cwt. of zinc, and 250 cwt. of brass are consumed yearly. Watchmaking, as a distinct art, is carried on still more extensively in the same locality.

Switzerland has long been celebrated for its watch-making. Swiss women are largely employed in certain parts of the trade, hence the minute delicacy and exquisite finish of the Swiss watches, so seldom to be found in those of English makers at similar prices. Manufactories are numerous at Geneva, the Hochthäler, and in the canton of Neufchatel. The number annually made in these districts is about 1,200,000. The all-important parts, such as the main-spring and the chains, are wrought by special artificers of approved skill. Machinery has recently been introduced both into Switzerland and France. Without such aid, Brukker's small brass clocks, which retail in London at five shillings each, would be a commercial impossibility. Large numbers are now produced at Besançon—about 28,000 in 1848, and 160,000 in 1856, of the total value of £320,000.

Excellent tower clocks are made in Munich, Dresden, Königsberg, Leipzig, Breslau, and Vienna. In the last-named city there are 228 large clock-makers, who manufacture annually from 100 to 150 iron tower clocks, 1,500 pendulum clocks, 400 bronze, and 600 wooden timepieces. Wagner, a German, has greatly improved the machinery of tower clocks, by employing cast-iron materials, and they have consequently been produced in his manufactory at one-sixth or even one-eighth the sum they cost twenty or thirty years ago.

America has extensive clock manufactures, on the factory system, chiefly in Connecticut. In one such factory 250 hands are employed, producing daily 600 clocks. Machine-stamped brass clocks are largely manufactured, and in the cheaper American kinds much woodwork is employed.

The French pride themselves on the exquisite beauty and finish of their ladies' watches; they cannot, however, compete with us in the art of making chronometers.

Throughout the world a good English chronometer is esteemed by nautical men as the very best that can be obtained. Nor is this a matter for surprise, when we recollect to what severe tests it is always subjected before receiving the sign-manual of the Astronomer Royal. All naval chronometers intended for Her Majesty's service must undergo a probationary stage of trial varying from six months to two years. The test takes place at Greenwich Observatory, under the keenest supervision; every specimen being exposed in the open air to the fiercest cold, and at other times to the air of a room heated to 100° Fahr. Greenwich Observatory is also the depôt for those manufactured for the public use.

In 1749, John Harrison received the gold medal from the Royal Society for his valuable horological improvements. Shortly after he applied to the Commissioners of the Board of Longitude to make a trial of his chronometer. An Act of Parliament entitled a successful candidate to £10,000 if the longitude were discovered within one degree, or sixty geographical miles; £15,000 if within forty miles, and £20,000 if within thirty miles. A voyage from Great Britain to any American port named by the commissioners was the proposed test. Permission for the trial was given, and his son William embarked at Portsmouth, Nov. 18th, 1761. After sailing for eighteen days, the longitude of the vessel was supposed to be 13° 50′ west of Portsmouth. The watch, however, making it 15° 19′, was condemned as unreliable. Harrison, nevertheless, maintained firmly and persistently that Portland Island, if correctly figured on the chart, would be seen on the following day. The captain was thus induced to continue the same course, and saw the wished-for land at 7 a.m. the ensuing morning. This raised Harrison and his watch in the estimation of the crew, who otherwise would not have been able to procure necessary stores during the remainder of the voyage. In like manner he was enabled by his watch to announce

all the islands in the order in which the vessel would fall in with them. After a second trial trip, to Barbadoes, Harrison became entitled to the parliamentary grant of £20,000, £10,000 of which were immediately awarded, the remainder to be paid when he had sufficiently explained to Maskelyne, Ludlam, Mudge, and other eminent men the principles upon which his chronometers were constructed. Harrison's success thus provided the seaman with a ready and accurate method for the determination of longitude at sea, and obviated the necessity for taking numerous observations and making tedious calculations. If ever a subject be wanted for a national picture, let us hope that the scene of "the trial of the chronometer" may not be forgotten.

Very extraordinary works of art, imitating life itself, were also made by the old mechanicians. Thus, Johann Hautsch, of Nürnberg (1595—1670), made a "self-moving chair" or sedan, and a four-wheeled wagon, moving without the aid of horses. In 1634—1703, his son, Gottfried Hautsch, presented to Louis XIV. a piece of workmanship by means of the wheelwork of which some hundred soldiers, horse and foot, were made to pass through the usual series of military evolutions. The figures made by Nancanson and Dvor in the eighteenth century were still more ingenious. Nancanson constructed automatic flute and flageolet players; the former forced air into the flute, regulating the notes with its fingers; while the latter, in addition to playing the flageolet, beat a tambourine with its hands. His masterpiece, however, was a duck, which dabbled in the water, swam, drank, and quacked like a real duck. It raised and moved its wings and dressed its feathers with its bill; it extended its neck, took barley from the hand and swallowed it, in doing which the natural motion of the muscle of the neck was perfectly perceptible. By means of materials provided for the solution of the food it had swallowed, digestion was imitated. The inventor

made no secret of the machinery, which excited great admiration at the time.

SECTION III.—THE MUSICAL INSTRUMENT MAKER.

At the period of the Reformation considerable attention began to be paid to the improvement of church music. In 1562, John Palestrina was allowed to remodel the old church style. A similar improvement was made, especially in Italy, in secular music, by the introduction of the opera, in which poetry and music were combined.

In Germany, from this epoch, music became a science. The choral system grew up in the reformed churches, and was brought to its greatest perfection by Bach (A.D. 1750) and by Handel (A.D. 1759.) Several eminent Roman Catholic composers have also appeared, such as Glück, Haydn, Mozart, Beethoven, and Weber.

Improvements in musical instruments, and in the preparation of wire strings and catgut, arose simultaneously. Violins were brought to such a degree of perfection in the seventeenth century that no further finish or refinement has since been made. Cremona, Brescia, and Innspruck were then, as now, the principal centres of their manufacture. In the preparation of catgut the Italians particularly excel, and in its manufacture they make use of the entrails of both sheep and cats. The best specimens are to be obtained from Rome, Naples, and France, those of French make being prepared in Paris, Toulouse, and Lyons. The lute was up to the time of Bach the favourite instrument. It was then superseded by the guitar, which came from Italy towards the close of the last century, but which, in various shapes, may be traced back to the remotest periods of antiquity. The guitar, especially popular in Italy and Spain, differs in appearance but little from the lute, except that it is lighter and more convenient for the performer. The harp of the Middle Ages was improved,

first, by Hochbrucker, in 1720, and then by Sebastian Erhard, of Alsace. The pedal harp was invented by Paul Vetters, at Nürnberg, in the first half of the eighteenth century.

Wind instruments were also extensively improved at the period of the Reformation. The first subjected to careful inspection and renovation was the organ. Hitherto the player had had very little command over the instrument, either in increasing or diminishing the sound. This defect was remedied by throwing aside the plan of separate registers, and separating the pipes by means of the spring and sliding boxes, thus dividing the influx of the wind. In the seventeenth century, Christian Tormer, of Wettin, invented the anemometer, which rendered it possible to distribute to every register or stop its requisite supply of wind.

In 1809 Bishop, of England, invented the composition pedal, for opening and shutting the stops by the foot instead of the hand, and also applied to the organ the anti-concussion apparatus. This latter prevented the concussion of the air in the wind-chest when a large number of pipes suddenly ceased sounding, and contributed largely to ease the labour of the player. Hill invented (1834-1836) the pneumatic lever and the syphon. He also built an organ in which the registering of the wind was performed by a tell-tale attached to the wind-chest. His *tuba mirabilis* introduced a new epoch into the history of English organ-building. Mr. Henry Willis invented a very ingenious pedal-valve, and also effected mechanical improvements for producing *crescendo* and *diminuendo* effects, enabling the organist, by one continuous movement, to draw or shut off any number of stops, instead of using many separate movements.

The three largest organs in Europe are St. Peter's, at Rome, with one hundred registers or stops; St. Michael's, at Hamburg, with forty-eight pedals; and the organ at Rothenburg, on the Tauber, upon which three performers can play at the same time. The following foreign church

organs are also deserving of being mentioned:—The organ in the Cathedral at Seville, in Spain, with its 100 stops and 5,300 pipes; and that in the church at Haarlem, containing 60 stops and nearly 5,000 pipes. The latter instrument is 108 feet in height and 50 feet in breadth. A church organ erected at St. Lawrence, in Rotterdam, is 150 feet in height, and has 5,500 pipes. The cathedral organ at Baltimore, in Maryland, has 36 stops and 2,213 pipes. This is the largest and finest toned organ in the United States.

Many of the large English organs are in no way inferior to these foreign instruments in tone, while they surpass them in mechanism and finish. Our finest examples are the new organ in York Minster, that in the Town-hall at Birmingham, and those of the Crystal Palace and the Albert Hall, South Kensington. The largest metal pipe in the York organ is 32 feet long and 22 inches in diameter; that in the Birmingham organ is 35 feet long and 21 inches in diameter; while that in the Albert Hall is 40 feet in length. In St. Patrick's Cathedral, Dublin, there is a magnificent organ presented by Queen Elizabeth.

Besides the organ, the instruments on which the pianoforte was based were greatly improved. In the sixteenth century they had a compass of but four octaves, and were adapted to the performance of the simplest melodies only. In 1711, Christopali, a harpsichord maker, of Padua, invented his *gravicembalo col piano e forte*, a term from which pianoforte is derived. In 1717 the pianoforte was still further improved by Schröder, of Dresden; and afterwards by Stein, of Augsburg. It was Sebastian Erhard, of Strasburg, however, who brought it to perfection. The first instruments had strings, some of steel and others of brass; at present they consist of steel wire throughout, with about an octave in the bass, closely lapped with unwashed copper wire.

The extent of the pianoforte manufacture in England and on the Continent is very considerable. Such firms as Broadwood's and Collard's, in London, keep timber in store for

many years. In France, and also in Germany, there are extensive piano manufactories. Paris has 150 makers, who employ nearly 2,000 workmen, mostly Germans. Workshops of an extensive character exist also at Vienna, Berlin, Munich, Cologne, Stuttgard, Breslau, Dresden, and Leipzig.

The accordion, concertina, seraphine, and harmonium owe their origin to the invention of the free reed, a vibrating tongue of metal, which gives forth a musical note when brought into contact with a current of air. The Chinese were acquainted with this principle, since both the Chinese organ and musical trumpet are wholly dependent upon it for their effects. The accordion, which came into England from Germany about the year 1828, is a rectangular box, varying from eight to twenty inches in length, and having in its interior a row of elastic metallic laminæ or springs. These are put into vibration by air supplied by a folding apparatus or bellows uniting the upper and lower parts of the box. This instrument is not limited to the production of melody, but produces harmonic combinations. In musical capability it is, however, inferior to the concertina invented by the late Professor Wheatstone. This last is composed of bellows with two hexagonal or other shaped faces or ends. On these are placed the various stops or studs, by the action of which air is admitted to the tongues or vibrating steel bars, which produce the sound; and on them are also fixed the thumb-straps and finger-rests. The accordion led to the construction of the seraphine, which may be described as an organ in which a free-reed stop takes the place of the pipes, the vibrating motion of the steel bars or laminæ being produced by air from bellows acted on by the foot. The seraphine was the predecessor of the harmonium. The best harmoniums usually contain twelve stops or draw-knobs, and, like the seraphine, are supplied with air by means of bellows worked by the foot.

As a natural consequence of such improvements, the art

of music has become widely spread through every grade of society. Saxon Voigtland supplies annually on an average 40,000 stringed and 60,000 wind instruments, besides 40,000 bass and violin bows. Fiddles are there made from the value of sixpence upwards, and violin bows at an equally cheap rate. In Prussia and Bavaria alone nearly 700 machinists and as many journeymen and apprentices are employed in the manufacture of musical instruments. Academies and schools have been established in many large towns for the further development of music as an art. A multitude of choral societies have been organised—in some instances even in villages—and in many places musical festivals are annually held. The Society of Arts of London, is now making strenuous efforts to promote musical education.

SECTION IV.—THE OPTICIAN.

The science of astronomy was revived by Nicholas Copernicus, of Thorn, in Prussia, who, together with other gifted men, published boldly the true theory of the earth's motion. His discoveries were made without the aid of any optical instrument, and even Tycho Brahé (born 1546), the greatest astronomer up to that time, made all his observations without the use of the telescope. In the thirteenth century distant objects were viewed through reed tubes without glasses. Friar Roger Bacon may have done more, but no one had yet hit upon the idea of a true telescope, which towards the end of the sixteenth century was invented in Holland, at nearly the same time, by three men—Hans Lippershey, Zacharias Jansen, and Adriaansz. It is at least certain that a telescope was made by Jansen, a spectacle-maker, residing at Middleburg, under the following circumstances:—His children, playing with his lenses on his work-table during his temporary absence, accidentally put two together in such a position that the weather-vane of the neighbouring church was enlarged and brought apparently

nearer. The fact was communicated to their father, who, with no greater object in view than the making of a toy with which his children might amuse themselves, fitted the two lenses to the ends of tubes of a corresponding diameter, making the smaller slide into the larger one, and thus constructing the first telescope. Galileo, the Italian philosopher, heard of this invention, and, after carefully examining Jansen's rudely-constructed instrument, so much improved it that he may truly be said to have first made it available for scientific purposes. Both Jansen and his son appear to have used their telescope in observing the heavens. This was after they had made the acquaintance of Galileo, who produced the first astronomical telescope. Its magnifying power was only three, and it consisted of a concave eye-glass and a convex object-glass, enclosed in a leaden tube. Kepler, a German astronomer, and friend of Galileo's, afterwards brought the instrument to greater perfection, and really invented a new one, which had two convex lenses, peculiarly adapted for astronomical observations. This telescope had a magnifying power of thirty, and with it Galileo made his chief discoveries. First he beheld the mountains of the moon, the height of which he measured by the lengths of their shadows; next the spots on the sun's surface, whereby he discovered the rotation of the sun on its axis; then the four satellites of Jupiter, a portion of Saturn's ring, the phases of Venus, and an immense multitude of fixed stars which hitherto had been beyond human ken. His last telescopic observations resulted in the discovery of the diurnal libration of the moon. Soon afterwards he was attacked with a disease of the eyes which in a few months rendered him totally blind. This calamity greatly distressed him, inasmuch as it incapacitated him from any other observations. In writing to a friend, he says: "Alas! your dear friend and servant has become totally and irreparably blind. These heavens, this earth, this universe, which, by powerful observation, I had enlarged a thousand times beyond the

belief of past ages, are henceforth shrunk into the narrow space which I occupy myself. So it pleases God; it shall therefore please me also."

While these discoveries were being made in Italy, Kepler was equally successful in his researches in physical astronomy in Germany. This extraordinary man, born at Wittemberg, A.D. 1571, discovered the cause of the tides, and laid down the three great laws of planetary motion, known as Kepler's laws—namely, the ellipticity of their orbits, the equality of the areas described by their radii vectors in equal times; and the sesquiplicate ratio between their periodic times and their mean distances from the sun. Kepler had been seventeen years engaged in the investigations which led to these results, and when he discovered them he was almost frantic with joy. "The die is cast," he exclaimed, "the book is written, to be read either now or by posterity—I care not which. It may well wait a century for a reader, as God has waited 6,000 years for an observer." These laws are contained in a work which he called "Harmonices Mundi." It was published in 1618, and was dedicated to James I. of England.

The telescope of Galileo was not sufficiently powerful to render visible the entire ring of Saturn; it showed that the disc was not round, like that of the other planets, but at the same time it merely revealed the extremities of the ring at its sides, as inequalities or convexities, which Galileo called "ansæ" or handles, and which he afterwards thought were two small planets. In 1655, Huyghens, by means of an improved telescope, detected one of the satellites of Saturn, and found that the inequalities seen by Galileo were portions of a ring which encompassed the body of the planet.

Improvements in telescopes and extensions of our knowledge of the heavenly bodies have since these times been repeatedly made; indeed, the telescope has now attained a degree of perfection such as Galileo and Kepler

could never have imagined. Newton was the first to effect the prismatic decomposition of light, and to show that the variously-coloured rays which form the solar spectrum, and which by their union make white light, are separated from each other and arranged in the spectrum according to their different degrees of refrangibility. To this cause must be attributed the coloured rays which fringe the margins of objects when seen through a telescope, thus rendering them to a certain extent indistinct. Mr. Dollond, a weaver, in London, was acquainted with this fact, and, in 1757, succeeded in making such an arrangement of the lenses as to destroy this chromatic aberration, as it is called. Thus the first achromatic telescope was constructed.

In 1663, Mr. James Gregory, of Edinburgh, in his "Optica Promota," proposed a plan for a catoptrical or reflecting telescope, which would magnify an image formed by a concave speculum. He even journeyed to London for the purpose of finding an artist who could make such a speculum; not being able, however, to discover one, the idea was abandoned. Newton took the principle up, and in 1669, having obtained a suitable metallic composition, commenced grinding with his own hands a speculum for a reflecting telescope, an operation which was completed in 1672. This telescope is still preserved in the library of the Royal Society. In the Newtonian telescope a concave speculum is placed at the closed end of the tube, to reflect the rays of light from the object viewed on to a small plane mirror near its focus, and inclined to the axis of the telescope at an angle of 45°. From the surface of this mirror, by a second reflection, the rays form an image, which is magnified by an eye-piece or simple microscope fixed opposite the mirror, in the side of the instrument. This telescope, which magnified from thirty to forty times, underwent, in the course of the eighteenth century, still further improvements, particularly at the hands of Sir William Herschel. The advance made was in the form and polish of the reflector.

Herschel's telescope differs only from Newton's in having no small plane mirror. It consists of a tube, the upper end of which is open, and turned towards the object to be examined, while a concave mirror, or object-glass, is placed at its further extremity, at such an inclination that the reflected image of the object may fall near the side of the tube, where there is a sliding apparatus containing an eye-piece, which magnifies the image thus reflected. This telescope was completed in 1789. It was 40 feet long, and magnified 1,000 times. The speculum was 4 feet in diameter, and weighed more than 2,000 lbs. The instrument was so mounted that, by means of ropes and pulleys, it could be moved by hand, and directed at pleasure to any part of the heavens. With it the Georgium Sidus and the division of one of Saturn's rings were discovered.

Even this immense instrument, and the larger one of Lord Rosse, in Ireland, were surpassed when, in 1814, Frauenhofer, in Munich, succeeded in producing achromatic telescopes of such clearness and magnifying power as to rival the best of known reflectors. Astronomers had thought it impossible to form perfect achromatic object-glasses of more than 5 inches diameter. Such glasses, however, have been successively enlarged far beyond this limit. A refractor which Frauenhofer prepared for the observatory at Dorpat had a focal length of 16 feet, an object aperture of 9 inches, and a magnifying power of 600. The Pulkova telescope, in the observatory of St. Petersburg, is still larger, being 24 feet long, and having an object aperture of 13½ inches. The workshop in which this instrument was made has since furnished two object-glasses, perfectly achromatic, of from 12 to 14 inches in diameter.

The astronomical discoveries above alluded to form but a part of all that have rewarded the labours of modern research and science. To mention more would be out of place here, especially as they are to be found enumerated in many modern elementary treatises on astronomy.

The Microscope.—About the same time that Jansen invented the telescope he also produced the microscope. A share, however, in the honour of this invention is justly due to Fontanus, an Italian, and to Cornelius Drebbel, an Englishman. The microscope is one of the most important instruments ever applied to the investigation of nature.

All objects are seen by reflected light, and subtend a greater angle in proportion to their proximity to the eye. A person walking across the street to read a placard more distinctly may be said to magnify it by his approach. At each step taken (supposing the eye to be still fixed on the placard) corresponding optical changes are made in the lenses and humours, in order to maintain distinct vision; but this power of natural adjustment has its limits. The following simple experiment will make this clear, and will at the same time explain the principle upon which microscopes generally are constructed:—Take a card, blacken its surface, make a small hole with a fine needle through its centre, and place the card about an inch from the page of this book. Look through the hole at the letters, and they will be seen distinctly and magnified. Suddenly withdraw the card, keeping the eye at the same distance, and the letters will instantly become indistinct and nearly invisible. This experiment proves—1st, that the naked eye cannot see at so small a distance as one inch, owing to the dispersion of the rays of light; 2nd, that a few of the rays are brought to a focus at the hole, enabling the letters to be distinctly seen; 3rd, that the letters themselves necessarily appear under a greater angle, and are therefore apparently magnified. Now, as the pierced card has enabled the reader to see the letters distinctly an inch off, and has at the same time magnified them, it is virtually a microscope as much as any lens or combination of lenses. The object of all the arrangements of lenses in every variety, both of simple and compound microscopes, is to produce a distinct image of the object,

and then so to refract the rays of light reflected from that image as to render it clearly visible at small distances from the eye. In simple microscopes one or more convex lenses are employed, whose magnifying power depends on their relative focal lengths, and that of the lens of the eye.

The simple microscope was undoubtedly the first used, and prepared the way for the much more valuable compound microscope. This microscope consists essentially of one or more object and eye glasses. By the former a magnified image of the object is refracted into the focus of the latter, which image is again enlarged or magnified by the eye-glass, which acts as a simple microscope. The compound microscope, therefore, in magnifying only the refracted image of an object, corresponds in principle to the reflecting telescope. For a long time the compound microscope remained in a very imperfect state, from the fact that there was a general ignorance how to get rid of the fringe of colour which Dollond had got rid of in the telescope. In 1816, however, Frauenhofer, of Munich, succeeded in making the first microscope with achromatic lenses. Since then it has been brought to an admirable degree of perfection by such artificers as Pflöffel, in Vienna, Shiek, in Berlin, Natchet, Chevalier, and Oberhausen, in Paris, and Lister, Ross, and Powel, in London.

The solar microscope is employed to produce a greatly enlarged image of a small object. The essential parts of this microscope are a mirror, a condensing lens, or series of lenses, and an object-glass. The sun's rays are caught by the mirror, which is so placed as to reflect them into the tube, whence they are refracted through the system of lenses and condensed on the object, the image of which is thrown in a magnified form upon a screen. It is obvious, however, that transparent objects only can be shown with this instrument. Instead of the sun's light, that of an Argand lamp was afterwards substituted; next ordinary gas-light, or carburetted hydrogen; then the dazzling light caused by an ignited jet

of oxy-hydrogen gas playing upon carbonate of lime; and lastly, the still more brilliant light produced by the galvanic battery when its poles are tipped with charcoal points. The oxy-hydrogen microscopes will become increasingly valuable for illustrating lectures on natural history and physiology. One made by Mr. Ross was used a few years ago at the Society of Arts, with perfect success, to illustrate a paper on the physiology of woods.

The microscope and telescope are well contrasted by Dr. Chalmers in the following language, which is as true as it is eloquent:—"The one leads me to see a system in every star, the other a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and its countries, is but a grain of sand on the high field of immensity; the other teaches me that every grain of sand may harbour within it the tribes and families of a busy population. The one told me of the insignificance of the world I tread upon; the other redeems it from all its insignificance, for it tells me that in the leaves of every forest, in the flowers of every garden, and in the waters of every rivulet, there are worlds teeming with life, and numberless as are the glories of the firmament. The one has suggested to me that beyond and above all that is visible to man there may be fields of creation which sweep immeasurably along, and carry the impress of the Almighty's hand to the remotest shores of the universe; the other suggests to me that within and beneath all that minuteness which the aided eye has been able to explore there may be a region of invisibles, and that could we draw aside the mysterious curtain that hides it from our senses we might see a theatre of as many wonders as astronomy has unfolded, a universe within the compass of a point, so small as to elude all the powers of the microscope, but where the wonder-working God can raise another mechanism of worlds, and fill and animate them all with the evidence of his glory."

Spectacles.—Spectacles were first used in Italy, about

the year 1285; and in the fourteenth century a man named Alexander employed himself there in producing them. The Minnesingers speak of them about this time as being used in reading, at the recommendation of physicians. Spectacle-makers were established in Nürnberg towards the end of the fifteenth century, when an opera-glass appears in a wood-cut. There are now in every large town in the United Kingdom, and throughout the Continent, abundant supplies of gold, German silver, and steel-mounted spectacles, suited to every variety of defective vision. At the Great Exhibition, in 1851, in the British department, spectacles were shown whose steel frames resembled hair-lines, quite imperceptible at a short distance. Some of these frames weighed only 11 grains, while the entire weight of the spectacles—glasses and frames—was only about 2 dwts. M. Henri, a French exhibitor, uniting the skill of a physiologist with the practical knowledge of an optician, exhibited spectacles having a movable diaphragm, capable of being shifted to the right or left at will, for the cure of certain defects arising from obliquity of vision. M. Pouillot showed metallic woven spectacles, which freely admitted air to the eyes, whilst at the same time they subdued the light, and served as a screen against dust and insects. These are now much worn by travellers.

The Camera Obscura.—Prior to the discovery of photography, this instrument was useful to artists and painters, since it enabled them to delineate objects with the greatest accuracy, both in respect of form and colour. The important part which it now plays in the beautiful art of photography has raised it to the rank of a truly philosophical instrument. The photographic camera differs but slightly in its form and principle from the camera obscura. It consists of a small rectangular box, having a tubular lateral opening, closed with a double convex lens. Placed before this is a diaphragm to assist in focusing the rays, which, passing through the lens, converge on an upright

screen at the back of the box. Different lenses and combinations of lenses are used in the photographic camera for portraits and for landscapes. The varieties of these instruments are even more numerous than their lenses; none of them, however, involve any material difference of principle. Mention might be made of the stereoscope, invented by Sir C. Wheatstone, and improved by Sir D. Brewster and others. The use of this is to give the appearance of solidity to flat delineations of objects, by causing two diverse pictures, representing the different appearances to the two eyes, to coalesce into one picture.

SECTION V.—THE PHILOSOPHICAL INSTRUMENT-MAKER.

It is impossible to study the physical and natural sciences successfully without the aid of suitable philosophical apparatus. In the preparation of these aids, science is not so much concerned as peculiar methods of handicraft. At the outset the implements required were made by the learned themselves. Afterwards, however, as the industrial arts advanced, craftsmen were employed, who, in the present day, form a separate branch of industry. Mechanical contrivances naturally enough improved as science progressed. Natural science during the Modern Period has been wonderfully advanced, and one result has been that mechanicians' work has become eminently important as a branch of labour.

As mathematical knowledge (which is the foundation of physical science) advanced, numerous accurately-constructed graduated appliances of ivory, wood, and metal became necessary. Our limits will only allow us to mention the names of a few of the most distinguished mechanicians who have either invented apparatus and instruments, or greatly improved the accuracy of such as were already in existence.

Joseph Being, of Hesse (1602), has had the credit given to him of the invention of compasses for measuring work.

As an instrument of philosophical use, however, it was evidently known to geometers and astronomers in Greece. The caliper compasses, whereby the bores of cannon and small-arms, and the diameters of cylindrical forms are measured, are believed to have been brought into use by a Nürnberg operative in 1540. Besides compasses, the instrument-makers produced an assortment of useful metal goods, both of fine and ordinary workmanship. In the industrial census of Nürnberg, in 1612, there were 100 masters of this skilled handicraft.

The primitive instruments—circles, surveying-rods, scales, astrolabes, and quadrants—were largely improved by Peter Apian, Gemma Frisius, and Tycho Brahé. The latter, indeed, constructed astronomical apparatus on a much larger scale than was ever done before; and the collection of mechanical contrivances in his observatory at Uraniburg was noted at once for its extent and value. The Roman abacus was employed in Europe to the end of the fifteenth century. In 1609, however, Geyger invented his calculating-tables, and in 1651 Napier his bones or rods. These last would have been doubtless more generally employed but for Napier's discovery of logarithms about the same time. Philip Harsdorfer made a calculating-machine, by the aid of which the highest numbers could be computed mechanically. Nonius, a Portuguese, discovered the contrivance in divided instruments called the "nonian," by which rectilinear degrees and circles were more accurately divided. Very ingenious and artistic machines on a similar principle have since been made. In 1553 the reduced or thousandth part scale was constructed by Johann Hommel, of Leipzig; the proportional circle probably by Fabricius Mordent, in 1556; and in 1611 the pantagraph, by the Jesuit, Christopher Schiener. The epoch from the beginning of the seventeenth to the end of the eighteenth century was noted for the discovery of new facts in science, and for novelties and improvements in mathematical and philosophical instruments. During this

period the reflecting sextant was invented by Hadley, an Englishman, and the repeating circle by Tobias Mayer; while Gascoigne, an Englishman, introduced the use of telescopic sights, and invented the micrometer. The first application of telescopes and micrometers to graduated instruments was made by Picard, who also invented the spirit-level, an instrument of inestimable value in surveying and civil engineering; and Ramsden, combining all these appliances, constructed the theodolite. Science with such aids made still more rapid advances.

Astronomical clocks, orreries, and globes, both celestial and terrestrial, were made. A machine for exhibiting the movements of the planets and their satellites about the sun was constructed at Nürnberg in the beginning of the sixteenth century by Bullman, and attracted universal admiration by its ingenuity. The first celestial globe was made by Martin Behain in 1418. Such apparatus and models appeared in course of time in a more complete form, especially in Nürnberg, as astronomy and geography advanced. Every boy is now enabled to learn what for thousands of years had been unknown to the greatest scholars—the general structure of both the earth and the heavens, the real and the apparent movements of the planets, with their accompanying satellites, and the connection which subsists between the movements of the solar system and those moving and sustaining forces which operate throughout space.

In England, George Graham, about the year 1700, invented the first machine of this nature, which simply exhibited the motion of the earth about the sun, and of the moon around the earth. This contrivance he placed in the hands of Rowley, an instrument-maker, to be sent with other patents to Prince Eugene. Rowley constructed a second for the Earl of Orrery, which was an improvement on Graham's. Hence the machine came to be called in England, an "orrery" (see "Course of Experimental Philosophy," by Desaguliers. 4to. London, 1734).

The pressure of the air, entirely unknown to the ancients, was discovered in 1645, by Torricelli, an Italian. The barometer for measuring this pressure was invented under the following circumstances:—Certain engineers employed in constructing a pump to raise water from a well of unusual depth found to their surprise that the water refused to follow the piston of the pump higher than thirty-four feet above its natural level. Galileo, being called upon for an explanation, is reported to have answered that Nature did not entertain the horror of a vacuum beyond thirty-four feet, afterwards acknowledging, however, that he had by no means given a philosophical answer. Torricelli, his pupil, conjectured that a column of mercury, which is thirteen-and-a-half times heavier than water, would be supported in the same manner, but to a proportionately less height. He therefore procured a glass tube, closed at one end and open at the other, and having filled it with mercury, inverted it in a vessel containing the same fluid. The mercury immediately sank in the tube to a level of about thirty inches, a height which bore the same proportion to that of the column of water that the weight of a given bulk of mercury does to that of an equal one of water. Torricelli concluded at once that the pressure of the atmosphere alone was capable of producing this effect, and thus practically confuted the ancient notion of Nature's horror of a vacuum, a dictum which had served the purpose of philosophy for upwards of 2,000 years. The experiment and its explanation soon became known throughout Europe, amongst others, to Pascal, who suggested that if the experiment were tried at a greater elevation, the mercury would have a less quantity of air pressing upon it, and thus the column would sink in the tube. The experiment was tried, therefore, on the top of the Puy de Dôme, Auvergne. The height of the column during the ascent was noted, and it gradually sank in proportion to the elevation, thus completely confirming Torricelli's explanation. Meanwhile other phenomena were manifested by the

mercurial column. The apparatus being kept for a length of time in an upright position, the height of the column was observed to vary daily between certain small limits. This effect was of course at once attributed to the variations in the weight of the atmosphere arising from various meteorological causes.

The following instruments subsequently invented have greatly increased our knowledge of the nature and properties of the aërial ocean:—The manometer, or dasometer, for finding the density or rarity of the atmosphere, was invented by Guericke, 1650; the anemometer, or wind-gauge, for measuring the direction and force of the wind, by Wolf, in the eighteenth century; the thermometer, which indicates the temperature of the atmosphere, was first made by Cornelius Drebbel, in the middle of the seventeenth century, and improved by Fahrenheit and Réaumur, in 1726; the pyrometer, for measuring very high temperatures, was invented by Muschenbroek; and the hygrometer, or measurer of the humidity of the air, by Wolf Leopold. The air-pump was invented in 1650, by Otto von Guericke, a burgomaster of Magdeburg; the air-gun by Marin, a Frenchman. Other inventions were speaking and hearing trumpets, and the tubes now so common in warehouses for conveying orders from the counting-room to remote parts of the building; the diving-bell, and the balloon. This last invention threw the world into unspeakable astonishment when the brothers Montgolfier, its inventors, first ascended in 1783. After them Blanchard and Jefferies, Rozier and his friend Romain, Garnerin, Gay Lussac, and Biot distinguished themselves as aëronauts. In 1804, Lussac and Biot, provided with philosophical apparatus for purposes of experiment, ascended from Paris to a height of 13,000 feet; while in the same year Lussac ascended alone to a height of 23,000 feet, the greatest elevation ever reached until the ascents of Green in 1838 and Glaisher in 1862. Very little in more modern times has been contributed to aëronautical science, and

the art of guiding balloons through the air has yet to be discovered. They have, however, rendered much service to meteorology in the last few years, under the auspices of the Aëronautical Society, and have recently been employed for military purposes. During the late siege of Paris they formed the principal means of communication between the besieged and the outer world. Balloons were formerly inflated with hydrogen, but common coal-gas is now used as a much cheaper substitute.

Electricity and Magnetism.—There is a power possessed by certain bodies, such as amber, when rubbed, of attracting feathers and other light substances. Thales (B.C. 600) was the first to observe this attraction, and after him Theophrastus. This power, however, does not appear to have excited any particular attention until about the end of the seventeenth century, when it was established as a scientific fact by William Gilbert, an English physician, and more completely by Otto von Guericke. The latter also invented the electrical machine. The electricity developed by his apparatus was allowed to escape, but in 1746 Cunœus, of Leyden, discovered a method of accumulating it by means of the Leyden jar.

The study of electricity was now further pursued, and the houses of electricians were crowded with spectators assembled to see the experiments. In 1747 a battery was contrived by Gralath, a German, in which the electric fluid could be accumulated in still larger quantities. This battery consisted of a series of Leyden jars united with each other, and charged and discharged in precisely the same manner as the single jar.

The similarity of lightning to the spark obtained from the electrical machine was quickly suspected by the first experimentalists; and in June, 1752, Franklin, by means of a kite flown during a thunder-storm, drew the electric fluid from the clouds into his Leyden jars, and performed the same experiments with it as with that procured from the

machine. A complete identity was thereby established. Similar results were also obtained about the same time in England, by Cavallo, and in France, by Messrs. Dalibard and Delor.

The practical mind of Franklin now suggested the protecting of ships and lofty buildings from electrical discharges by means of lightning-rods. Wires were thenceforth used by electricians for making observations on atmospheric electricity—experiments, let it be remembered, that were attended with alarming danger, as was shown at St. Petersburg, in 1753, in the death of Richmann, who was killed in his apartment by the discharge of the electric fluid whilst using the apparatus during a thunder-storm.

Electricity is now known to be one of the grandest and mightiest of natural agencies. This power has been so utilised that the most important results for the service of man have been effected by it. The fatal flash from the heavens has been drawn to the earth and rendered harmless; water has been decomposed into its elementary gases, and our communications conveyed to great distances by its agency in a brief space of time.

In 1790 galvanism, or voltaic electricity, was discovered by Galvani, an Italian philosopher. Soon after the discovery, Volta, his countryman, constructed the battery called the "voltaic pile." This ultimately led to other and still more powerful combinations—to the construction of galvanic batteries sufficiently energetic to deflagrate metals, decompose water and the metallic oxides, and to produce the most brilliant and far-reaching light. This electric light served to illumine the docks at Cherbourg, while the workmen were employed in their excavations; and in the late war was occasionally used by the besieged in Paris to illumine the enemy's position, and thereby enable them to take sure aim. It has also been substituted by M. Foucault, and with great effect, for the lime-light in the oxy-hydrogen microscope. Very useful forms of the voltaic battery have

been contrived by Cruikshank, Wollaston, Groves, Daniell, and Bunsen; and several beautiful and successful applications of voltaic electricity have been made by Faraday and his followers.

A few fishes—the torpedo, the gymnotus of South America, the silurus of some African rivers, and two species found in the Indian Ocean—discharge electricity, either in self-defence or when in the pursuit of prey. Linari succeeded in isolating the electricity from the gymnotus, and proved it to be identical with that obtained from inorganic sources.

The fact that electricity was capable of inducing and destroying magnetism was well known to Franklin, Neccaria, and others from the effects of lightning on the polarity of the compass during a thunder-storm, and by its capability of imparting polarity to small steel articles. It was not, however, until 1819 that the laws of these phenomena were discovered by Professor Oersted, of Copenhagen, who was the first to make the great and invaluable discovery of the action of the galvanic current on a magnetised needle. He thus laid the foundation-stone of the science of electro-magnetism. Shortly after, Arago and Ampère, of France, and Seebeck, of Berlin, succeeded in rendering iron magnetic by the passage of an electric current through a wire coiled about the iron; while Sturgeon, in England, also produced an electro-magnet. The invention of the voltaic battery, the discovery of the deflection of the magnetic needle, and the magnetisation of soft iron, prepared the way for the electric telegraph, which, through the genius of Gaus, Weber, Steinheil, Cooke, Wheatstone, and Morse, has now been brought into common use. Even so early as 1746, Winkler, in Leipzig, and, in 1807, Sommery, in Munich, made attempts at telegraphy, but with little success till the great electro-magnetic discovery was made and applied.

The great use which has been made of the electro-magnet in telegraphy has led to many investigations as to

the best means for increasing its power and giving it permanency. Electro-magnets are now bent into a horseshoe shape, and encompassed with an armature consisting of a helix of wire covered with silk or gutta-percha. Under the influence of a current of electricity, generated through the helix by a voltaic battery, they are capable of supporting, it is said, more than a ton weight. This powerful magnetism, however, only continues so long as the current is kept up, ceasing the moment that it is interrupted. If, nevertheless, the iron about which the helix is coiled is combined with sulphur, carbon, or phosphorus, and then exposed to the influence of the current, its magnetism becomes, to a greater or less extent, permanent. In this manner new magnets of iron are made, and large stores of magnetism accumulated. It is plain that these facts all tend to establish the theory of Ampère as to the cause of the polarity of the magnet—namely, that it results from the presence of active electricity in the form of continuous electrical currents, which are ever circulating about the magnet itself and around the minutest particles of which it is composed.

The polarity of the needle is most unquestionably to be attributed to the magnetism of the earth itself. The causes of this magnetism have still to be discovered, but the fact is certain. The whole globe is pervaded by this unknown power; or, to state the fact with greater exactness, the crust of the earth is the seat of the magnetic current. The attention of scientific men throughout the world has, therefore, of late years been specially directed to terrestrial magnetism. The variations of the dip of the needle have been noted in different parts of the earth, and they have disclosed the fact that the earth herself acts as a great magnet, having two magnetic poles, not far from her poles of rotation. This is known from the circumstance that the needle is vertical at those points, whilst it dips from either pole until the a circle or line midway between them is

reached, called the magnetic equator, where it is perfectly horizontal. It therefore follows that the needle does not point exactly north and south, which would be the case if the magnetic poles coincided with the poles of rotation, but points to either magnetic pole. This produces that deviation from the geographical meridian known as the variation. The extent of this variation is at present in London 26° and in Boston $5\frac{1}{2}^{\circ}$ to the west of north. Columbus nearly lost the honour of being the discoverer of America from this cause, for as he voyaged onwards he found the needle, instead of being true to the pole, gradually deviated more and more to the north-east; and we can scarcely wonder at the sailors, ignorant of the true cause of this, wishing to return, under the belief that the virtue of the compass was gone. It has also been discovered that the needle makes movements of very small extent daily, monthly, and yearly, and that it undergoes simultaneously, in different and remote parts of the earth, sudden and irregular disturbances, which have been attributed to magnetic storms.

Until 1828 there was no systematic method of observation adopted in reference to terrestrial magnetism. Since then magnetic observatories have been established in England, other parts of Europe, and the United States. An immense number of facts have consequently been accumulated, and from these data magnetic charts have been constructed, which present, at one view, the variations and dip of the needle for all parts of the world. Forms of apparatus have also been invented, especially by Fox, which calculate most accurately the magnetism of the earth.

Telegraphy.—An electric telegraph consists of three principal parts—first, the apparatus for generating the electric action, this being usually either a voltaic battery or a magneto-electric machine; second, the electrode, or insulated path along which the electricity must travel, familiarly known as "the line," or, in the submarine telegraph, "the cable;"

third, the instrument at each end of the line, used to record the signals forward and through the transmitting apparatus. At the present time almost every place of commercial importance is furnished with means of telegraphic communication, and telegraph lines run along the sides of every railway and not a few ordinary roads.

Submarine telegraphy is now in successful operation. In 1850 the wires were laid between England and France, and in 1853 between England and Belgium. France and Britain are both connected with the United States by submarine cables, Europe and Africa by a cable under the Mediterranean Sea, and Europe and India by two lines of telegraph, partly submarine, partly terrene. The beautiful experiments of Professor Wheatstone on the velocity of electricity have shown that the current travels at the rate of upwards of 200,000 miles per second. Communication, therefore, may be said to be instantaneous. The electromagnetic telegraph is, in short, one of the most wonderful and useful applications of science yet made. Unlike anything in the previous history of the world, it virtually annihilates both time and space.

Chemical Apparatus.—As with mathematics and natural philosophy, so with chemistry, every advance has been made by the aid of instruments produced by diligent and skilful mechanicians; by the help of these, learned and scientific men, such as Berzelius, Dalton, and Faraday, have carried on their experiments. Of the many instruments which are used in the laboratory of the chemist, we may mention here the various apparatus invented by Gorey, Humboldt, and Girtanner for obtaining and applying oxygen, and the different weighing and measuring instruments, such as the eudiometer, for ascertaining the proportion of gases in the atmosphere, invented by Priestley, Hope, Ure, and Henry; the differential thermometer, by Leslie; the mercurial thermometer, by Fahrenheit; the centigrade thermometer, by Celsius, a Swede; the

cyrophorus, or frost-bearer, by Wollaston, for freezing water by its own evaporation; the calorimeter, by Lavoisier and Laplace, for determining specific heat; the hydrometer, by Sykes, for determining the specific gravity of fluids; and gasometers, by Fontaria, Scheele, Lavoisier, Davy, and others.

A large variety of chemical and mechanical apparatus has been called into existence for the purpose of facilitating work in the laboratory, such as Pepy's gasholders, and numerous articles in glass, earthenware, porcelain, and metals. There are, also, in common use, retorts, test-tubes, funnels, specific gravity bottles, graduated measures, crucibles, evaporating dishes, retort stands, and chemical balances.

Commercial men, whilst understanding that the accurate determination of a standard of weights and measures is entrusted to men of science, are little aware of what the task involves. The size and weight of the earth must first be ascertained. Its dimensions have been determined by the exact measurement of a meridional arc of the heavens corresponding to a given distance between two points on its surface, and by the determination of the difference in the length of a pendulum vibrating seconds in different latitudes. The mean density has been ascertained to be five and a half times that of distilled water, by calculating the amount of attraction exerted by a mountain of known dimensions upon the bob of a plumb-line, as shown in the amount of deviation of the latter from the perpendicular. In both instances, the most accurate scientific measurements with the best instruments were absolutely necessary.

The length of a pendulum vibrating seconds in the latitude of London was found by Captain Kater to be 39·13929, when oscillating *in vacuo*, at the temperature of 62° Fahr., and reduced to the level of the sea. The weight of a cubic inch of distilled water at 62° Fahr., the

height of the barometer being thirty inches, was also determined in parts of an imperial troy pound. From these data the standard of length called a yard, and the standard brass weight of one pound "troy," are fixed with precision.

Now, although the invention of philosophical instruments is generally to be attributed to those whose whole lives are devoted to the careful observation of natural phenomena, yet there have been many mechanicians who have shown superior ability in planning and a skilful hand in executing. No other handicraft approaches so closely to science as that of the mechanician. The philosophical instrument-maker, to be a master of his craft, must possess considerable scientific knowledge, and more especially an acquaintance with mathematics and physics. This branch of industry is everywhere advancing, and rapidly keeping pace with the progress of science. In the fabrication of their instruments, Germany and England hold the foremost places; their productions are of the most accurate and durable character, and are sent to all parts of the world.

SECTION VI.—UTILITY OF CHEMISTRY.

Whenever increase or decrease of heat takes place, wherever substances in combination are separated, wherever the union of simple substances and the formation of new compounds are effected, the operations in part at least, are dependent on chemical principles. The bread that we eat, the wine and beer that we drink, the gas which lights our streets and houses, the colour of our clothes, the leather of our boots, the money in our purse, the ink which we use, do not all these owe their production or their perfection to chemical processes? In the arts of extracting metals from their ores, of purifying them, and combining them with each other, almost all the methods are purely chemical.

Chemistry, moreover, gives us the means of correctly

appreciating the quality or value of natural and artificial products; it enables us to detect adulterations, and it determines the means to be employed in neutralising the defects inherent in much of the raw material derived from natural sources.

Historical Sketch of the Progress of Chemistry.—Though the Alexandrian school had attained correct views respecting some of the dynamical and statical properties of fluids, yet chemistry had little or no place among the Greeks, and it was not until after the decline of the Roman Empire (about 900 years later) that the cultivation of this branch of science was commenced with some success by the Saracens.

About the middle of the eighth century a foundation for chemistry was laid by the discovery of strong acids and explosive mixtures. For more than a thousand years the chief object of most chemical labours had been the search for the "philosopher's stone." This stone was supposed to contain the three primary essentials of earthly happiness. It was also considered to have the power of transmuting the baser metals into gold. Alchemy, or the transmutation of metals, was virtually the parent of the modern science of chemistry. That the alchemist, in spite of the wildness of his aims, was to some extent a scientific investigator, is proved by the remarkable definition given of alchemy by an Arabian writer. He calls it the science of the balance, the science of weight, and the science of combustion.

The writings of Geber, who flourished in the eighth century, give evidence of an extent of chemical knowledge and of facts experimentally established which excite our admiration and wonder. Djafar, who also lived towards the close of the same period, gained considerable renown by the discovery of nitric acid and aqua regia. By this latter he dissolved gold. His doctrine respecting the nature of metals, although erroneous, was not without scientific value. He knew that a metal when calcined increased in

weight, and he described the operations of distillation, sublimation, and filtration, together with various chemical apparatus.

Next came Rhazes (A.D. 860), who prepared and described the properties of sulphuric acid; Achild Bechil obtained phosphorus; and after him there existed among Arabian physicians generally considerable chemical knowledge. "While the Arabs," says Draper, "joined in the pursuit of alchemy, their medical tendencies led them simultaneously to cultivate another ancient delusion—the discovery of a universal panacea or elixir which should cure all diseases, and prolong life for ever. The effect of the search for the elixir established the principles of relieving the diseases of the human body by purely material means, and as the science advanced, it gradually shook off its fetishisms."

Paracelsus took chemistry out of the hands of the gold-seekers, and brought it into the service of the physician. He and his followers, it is said, prepared their own medicines. Thus it arose that chemical knowledge and an acquaintance with chemical operations were regarded as among the most essential qualifications of the physician and for the science of therapeutics.

The theories of Roger Bacon and Albertus Magnus, the great philosophers of the thirteenth century, for their fertility of ideas and their comprehensive views for nature, may be fitly compared with the researches of modern schools of chemistry.

During the sixteenth and seventeenth centuries alchemists were found in the courts of princes, and men of all ranks studied the transmutation of the baser metals into gold; and though the false views respecting chemistry and natural science which were held seemed little likely to lead to truth and progress, yet the influence of the idea was not without value, because, in order to know the existence of gold, it was indispensable that every substance accessible to study

should be observed and tested accordingly. It is difficult to form a just conception of the difficulties which the alchemists had to overcome in their researches. They were of necessity the inventors not only of the apparatus and instruments, but of the processes which they employed. They were without those means and implements which we make use of, and which have so materially contributed to the progress and development of modern chemistry. Liebig writes that "without glass, cork, platinum, and india-rubber, we should probably at this day have advanced little. In the time of Lavoisier only a few, and those very rich persons, were able, on account of the costliness of apparatus, to make chemical researches."

Modern Chemistry.

Alchemy merged into chemistry through the successful labours of Stahl applied to the theory of phlogiston. This theory accounted for the change that metals undergo when exposed to fire by the principle that as something is thrown off, so something may be restored by the action of combustible bodies. Such a doctrine was found to include the cases of combustion, the production of acids, and the breathing of animals. On its ruins arose the theory of oxygen, though it maintained its ground even long after the discovery of oxygen by Priestley in 1774, and by Scheele in 1775. The weak point of this theory was that when a metal is burnt the product ought to be lighter than the metal, whereas in reality it proves to be heavier. At length the masterly researches of Black formed the groundwork of the anti-phlogistic chemistry. He detected that the increase of weight in quicklime exposed to the air depended on the absorption of gas (carbonic acid) from the atmosphere, which gas could be expelled by heat. He pointed out, also, that the lime had gained a weight equal to that lost by the air.

This discovery shows that the balance had been re-

sorted to for the determinations of the weights, and for the decision of physical questions. This use of the balance inaugurated the epoch when chemistry ceased to be exclusively a science of quality. Henceforth it became a science of quantity also. The fundamental experiment of Lavoisier, the calcination and reviving of red oxide of mercury, and the absorption and reappearance of an ingredient of the air in these processes, is in principle the same as Black's.

The great discoveries of Black and Lavoisier are due to the balance; no wonder, then, that before the time of Lavoisier and his contemporaries no exact analysis was possible, that industry progressed at haphazard, that the manufacture of the principal products was made in most cases from empirical recipes. The balance made by Ramsden for the Royal Society is capable of weighing ten pounds, and turns with the hundredth of a grain. Its delicacy is such that its indications are affected by the observer's position before it, that arm of the beam preponderating opposite to which he stands, in consequence of its becoming expanded by the radiation of heat from his body.

The artificial decomposition of water in 1781, by Cavendish and Watt, constitutes another era in the annals of chemistry. More correct views of the nature of chemical affinity and of the composition of bodies were obtained; the old idea of four elements was discarded, as also the Saracenic doctrine of salt, sulphur, and mercury; the known elements were increased, until at present they number sixty-five.

The introduction of the balance was followed by important consequences in theoretical chemistry, pre-eminent among which was the establishment of the laws of chemical combination. The first foundation of a complete system of equivalents, embracing both simple and compound bodies, was laid by Dalton, in 1808, when he announced his famous atomic theory.

Chemistry appears to have made but little progress until

towards the close of the last century, by which time the researches of illustrious men had raised it to a foremost place amongst the exact and applied sciences. Amongst those men of genius and learning who so largely contributed to its establishment on a firm foundation, may be mentioned the names of Lavoisier, Richter, Wenzel, Proust, Cavendish, Watt, Berthollet, Priestley, Black, Scheele, and Dalton. Of these, Lavoisier holds the first place. It was he who investigated the composition of the atmosphere and of water. During his time the number of known metals was increased from eighteen to thirty-two. He proved and proclaimed the grand and fundamental principle that nothing in nature is lost, that the bodies which to uninformed minds are destroyed, are changed only in form. The influence that this principle was to exercise upon industrial processes was great.

It must not be said, however, that nothing had been done in chemistry before the age of Lavoisier. There is no doubt that a great number of chemical products and processes had been bequeathed by the generations which had preceded. Still, this long antecedent period is, comparatively speaking, poor, both in invention and in application. It is especially to the thorough investigation of the chemical properties of bodies and the study of their reciprocal actions that are attributable so many of the more important industrial discoveries of the present century. Amongst these may be indicated the detergent and disinfecting action of chlorine, the manufacture of sulphuric acid, of coal-gas, of carbonate of soda, and especially of sugar from beet-root.

Illustrations of the Influence of Chemistry upon the Progress of the Industrial Arts.

Beet Sugar.—In 1747, Margraff discovered the presence of crystallisable sugar in beet-root. The importance of this fact passed unnoticed, and it was fully fifty years after the discovery that Achard essayed to commence its manufacture. It was, nevertheless, not till 1811 that success was

obtained. At this period, and in spite of the encouragement of the learned chemist Chaptal, then minister of the French Empire, the manufacture of sugar was limited to a few establishments, and the annual production did not exceed 12,000,000 or 14,000,000 lbs. At the present day it is estimated that Europe possesses more than 800 sugar factories, furnishing for general consumption 1,500,000,000 lbs. of beet-root sugar yearly.

Sulphuric Acid.—During the ninth century sulphuric acid was known to Rhazes, who obtained it by the distillation of green vitriol or sulphate of iron, as did Basil Valentin and all succeeding chemists to the end of the seventeenth century. Lefevre and Lemery originated the employment of a mixture of sulphur and nitre, which was introduced into a large glass flask filled with a moist atmosphere; the bottom of the flask was covered with a little water, to serve for the condensation of the acid produced. The manufacturing process for sulphuric acid is older than the theoretical explanation of what actually occurs; and although, as we have seen, the acid itself was generally known long before, the commercial manufacture dates from the invention of the leaden chambers, the first of which were erected in 1774, by Roebuck, of Birmingham. It may be stated, in passing, that the cost of the acid was considerably diminished by this process. "Sulphuric acid," says M. Dumas, "is an indispensable agent in all the arts, and the majority of them have only originated since its price has been reduced to about that at which it is now quoted in commerce."

Phosphorus.—Phosphorus, that mysterious body which gave rise to so many wild speculations and theories, has now become one of the most useful and most common substances of every-day life. Long after its re-discovery by Brandt, in 1667, it remained only a curiosity of the laboratory; indeed, it was as costly as gold. It has now, however, replaced the old-fashioned flint and steel, and can be obtained at a very cheap rate. To the chemist, who has modified its

properties, society is deeply indebted; by allotropy he has suppressed its energetic and pernicious action, and, at the same time, has preserved its inflammability.

Oxalic Acid.—In 1829, Gay Lussac discovered that all the neutral matters of vegetable origin, such as starch, sugar, ligneous fibre, gum, and the like, are transformed into oxalic acid upon coming in contact with alkalies heated to a temperature of about 250° centigrade. This discovery, the industrial application of which has till recently been neglected, has resulted in the erection of considerable chemical works, in which Mr. Deake, of Manchester, prepares more than 300 tons of oxalic acid per annum.

Carbonate of Soda.—The mode of manufacturing carbonate of soda from common salt, now very generally adopted, was the invention of Leblanc at the end of the last century. Soda has been used from time immemorial in the manufacture of soap and glass. Before the Revolution of 1780, no other soda was known in France than that obtained from marine plants, and this for the most part was imported from the coasts of Spain. The wars of the Republic naturally checked this and other resources of native industry, and it was not until Napoleon offered a prize, adjudged to Leblanc, for the best process of preparing soda that that material was manufactured in its present improved condition. This process at one time threatened the existence of the manufacture of soda-ash by the incineration of marine plants, so extensively carried on in Alicante, Narbonne, Scotland, and Ireland; but the discovery of iodine has given a new impulse to the latter mode, and rendered it more prosperous and important than ever.

Bleaching-powder.—In the first process in the manufacture of carbonate of soda, the action of the sulphuric acid produces hydrochloric acid gas to the extent of one and a half times the amount of the sulphuric acid employed. This was formerly allowed to escape into the atmosphere, to the destruction of the surrounding vegetation. Now, how-

ever, it has a commercial value, and is applied in the manufacture of bleaching-powder (chloride of lime) a new and most important substance largely used in the cotton manufacture.

Stearine.—About the year 1823, M. Chevreul, after great and laborious research, proved that the majority of fatty bodies were only mixtures of different neutral compounds. No one imagined at the time that this discovery would play such an important part in commerce as it has done. Amongst the proximate constituents of tallow, there are some which possess a much higher melting point than tallow itself, and at common temperatures are firmer, drier, and even brittle; in other respects they are quite analogous to fat, but do not feel greasy. In short, these constituents possess in the highest degree those properties which manufacturers have endeavoured to confer upon tallow by the different modes of hardening; but it was only in 1823 that Gay Lussac attempted to apply the results of the labours of Chevreul. The first effort failed, but in 1831 all the difficulties in the manufacture of stearine candles were overcome by Cambacérès. The introduction of the cheaper paraffine candles has partially superseded those made of stearine. Allied to stearine, and now manufactured more largely than that substance, is stearic acid.

Paraffine.—The researches of Reichenbach, in 1830, on the products of the destructive distillation of wood, lignite, and turf, led to the discovery of a solid substance imperfectly transparent, and perfectly combustible, called paraffine. Twenty years, however, elapsed before this substance was obtained in a condition to become of general use. The problem was solved in 1850, by James Young, who, in 1851, erected a paraffine manufactory at Bathgate.

Gas Illumination.—The observation was made in the year 1664 by Dr. Clayton, that combustible illuminating gas was produced during the decomposition of coal by heat, and that this might be collected. One hundred years

afterwards, an application of the discovery was made, and in 1786 Lord Dundonald built coke furnaces, collected the evolved gases in tubes, and burnt them, but without any definite object. Murdoch occupied himself incessantly with experiments on gas illumination from 1792 to 1796, and in 1798 erected a gas-work for lighting the manufactory of Boulton and Watt. Independently, and about the same time, Le Bon, a Frenchman, succeeded in illuminating his own house by an apparatus in which he evolved poor gas from wood. London was lighted by gas in 1812, and Paris in 1819, since which time gas has been generally introduced into the larger towns throughout the world. Mr. R. E. Taylor states, in the *Philosophical Magazine*, March, 1846, that the Chinese were acquainted with the use of coal-gas, both for illuminating and heating purposes, long before it was known to the Europeans.

Coal-tar Products. — Among these, attention may be directed to those hydro-carbons which in the state of purity have received the name of "benzine," or "benzol," and which constitute in part the limpid and inflammable liquid known in commerce by the name of "naphtha." The discovery of this substance is due to Faraday, who, in 1825, obtained it in the process for purifying oil-gas. In 1834, Mitscherlich obtained this volatile oil by distilling a mixture of benzoic acid with an excess of lime, hence the name; but neither the one nor the other of these processes was suited for its extensive manufacture. It was not till 1845 that Hofmann discovered the presence of benzol among the minor products obtained during the purification of coal-gas, and, three years later, Mansfield showed how it might be obtained from coal-tar on a large scale.

Among the modifications which benzine undergoes with various chemical agents, we may allude to the substance known under the name of "*essence de mirbane*," because of its possessing an odour like that of the essence of bitter almonds. Collas was the first to prepare it on a commercial

scale. Among its minor uses are those of imparting an agreeable smell to cosmetics and a flavour to wines and confectionery. Mitscherlich made this his special study, and after him Zinin first, and then Bechamp, whose labours resulted in the conversion of nitro-benzine into aniline, a kind of ammoniacal compound, which had been extracted from indigo by Unverdorben as early as 1826. Its name, "aniline," is derived from the scientific denomination of the plant (*Indigofera anil*) whence it was obtained. Owing to the recent and remarkable experiments, first of Perkins, then of Wurtz and Hofmann, aniline has come to be used as the basis of many new colouring matters, such as mauve, magenta, &c. The most marked colouring power is possessed by fuchsine, the salts of rosaniline, the manufacture of which has lately acquired so much importance.

The substance deposited in the gas-mains, which blocks them up even at a distance from the works, and which causes an impediment to the efficient delivery of gas, is a crystalline hydro-carbon named "naphthaline." Many attempts had been made to utilise naphthaline as a source of colour, but for a time without success. Martius and Griess, however, succeeded, about three years since, in producing a beautiful and permanent yellow dye, capable of communicating any required shade, from bright citron to golden yellow.

The discovery by Grübe and Liebermann of the artificial preparation of alizarine from anthracene, a substance found in coal-tar, has been supposed by some to involve the gradual abandonment of madder agriculture, but there are quite as many who dispute this probability. Alizarine is the most important constituent of madder dye, and with the ordinary mordants yields the same colours. The colours derived from lichens, dye-woods, and cochineal have been to some extent displaced by coal-tar dyes.

Artificial ebony is now being manufactured on a tolerably extensive scale. It is prepared by taking sixty parts

of seaweed charcoal, ten parts of liquid glue, five parts of gutta-percha, two and a half parts of india-rubber dissolved in naphtha, ten parts of coal-tar, and five parts of powdered resin, and heating the mixture to about 300° Fahr. Thus obtained, the mass, as regards colour, hardness, and capability of polish, is equal to ebony, and much cheaper.

Ultramarine.—From time immemorial ultramarine has been known as a beautiful colouring material, in grea demand among painters. But its price—higher than that of gold—compelled many artists to abandon its use, and to employ in its place inferior colours. The artificial production of an ultramarine, a substance which should displace the mineral colour which is extracted with so much difficulty and sold at so high a price, was long sought. The exact composition of ultramarine was unknown, so that the first step towards the solution of the problem was unattainable; but eventually chemical analysis put us in possession of its constituents. Hope was thus held out that the material would at some future time be obtained by synthetical processes; and now, by simply combining in the proper proportions, as determined by analysis, silica, alumina, soda, iron, and sulphur, thousands of pounds' weight of artificial ultramarine, surpassing in beauty the natural and original colour, are manufactured. For the price of a single ounce of the one many pounds of the other may be procured.

Aluminium.—In the last few years the same substance which forms the basis of ultramarine has become the source of the metal aluminium, the properties of which have been described by M. Deville. In its brilliant lustre and its whiteness it rivals silver; indeed, in a great number of cases a preference is given it, on account of its lightness and less liability to tarnish. Although it can be separated from the earth alumina or from the chloride, yet it is found more economical to obtain it from the mineral cryolite, found in Greenland.

Platinum.—This metal was first discovered by Ulloa in 1735, and Dr. Wollaston discovered a method of fusing it, and thus rendering it available in the arts. We may judge of its utility from the fact that sulphuric acid manufacturers, notwithstanding its great cost, generally employ it for their retorts, in the concentration of sulphuric acids, the danger and great loss by breakage attending the use of glass vessels having made this substitution advantageous. These platinum retorts are made, for the most part, in Paris, weigh from 5 cwt. to 20 cwt., and cost from £1,700 to £2,600. The joints in the retorts are soldered with gold, and more than one retort is required in each chemical manufactory. The extended application of platinum demanded an improved method of fusing it, which was devised by MM. Deville and Debray. An ingot of platinum, weighing more than 700 lbs., was exhibited by them at the London Exhibition.

Silvering Mirrors.—About forty years since, Liebig determined the fact that aldehyde, discovered by Döbereiner, possessed the property of reducing the salts of silver, thus causing the precipitation of metallic silver as a reflecting surface on glass. This property, common to some other organic compounds, has recently been utilised in the arts, and to this we owe the silvering of the spherical mirrors now largely employed as household decorations. If this process were more generally adopted, in place of the ordinary tinning of glass, chemistry would thereby render a great service to hygiene; it would diminish the number of workmen subject to the dangerous and often fatal influence of mercurial vapours.

Electro-metallurgy. — Voltaic electricity, a force which so materially influences chemical decomposition, has been made in many ways subservient to the progress of industry, as alluded to already.

Photography.—Photography affords a most remarkable example of the application of chemistry to the arts. The

word, from its etymology, means "light-writing." The photographic process is based upon two chemical principles—the one that a salt of silver (such as the chloride, bromide, or iodide) is blackened by light; the other, that the unblackened or undecomposed combinations of silver are soluble in sodic hyposulphite. For this reason, the blackened and unblackened surfaces can be permanently separated. The photographic art took its rise in the experiments made by M. Daguerre, of Paris, and Mr. Talbot, of London, the latter of whom endeavoured to produce photographs on paper, the former on silver-gilt copper plates. Mr. Talbot's experiments were only partially successful, for the process involved a long exposure of the surface to the influence of the light. M. Daguerre at first met with the same difficulty, but accident revealed a method of overcoming it.

Daguerre exposed his plates to the action of iodine vapour, and thus coated them with a thin film of argentic iodide, but failed to produce upon them a visible picture. These plates were laid aside in a cupboard containing various chemical substances and apparatus. Taking out a plate one day, Daguerre, to his surprise, found upon it a picture perfect to the most minute details. Amongst the articles in the cupboard was a vessel containing mercury. After removing the other contents of the cupboard article by article, Daguerre still found that the pictures were produced on the plates, and was forced to the conclusion that their production was due to the vapour of the mercury which filled the cupboard.

Mr. Talbot overcame the difficulty inherent in his process by the use of gallic acid, a substance producing effects analogous to those caused by light, but very much stronger.

Amongst the improvements which have shortened and otherwise improved the process may be mentioned the combination of bromine with iodine, first used by Mr. Goddard in 1840, the employment of collodion by Mr. Scott

Archer, and the substitution of a solution of ferric sulphate for gallic acid by Mr. Hunt. After the picture is produced upon the plate, its permanency is secured by dipping in sodic hyposulphite. The process, in so far as described, produces what is called the negative picture, because in it all the lights and shadows of the original are reversed. The positive picture is obtained by a process of photographic printing, into which it is not necessary to enter here.

Photography in its present perfected state enables pictures to be made of effects the most transient and instantaneous, such as the dance of the wave, the passage of a rapid train, the flash of a meteor. Its most common application is to portraiture; but it has been applied by Mr. De la Rue to the more scientific purpose of picturing the phases of the moon and the fiery prominences seen during a total solar eclipse.

Spectrum Analysis.—This most remarkable agent of scientific investigation is due to the labours of Bunsen and Kirchoff. It is based upon the following principle: If non-homogeneous light, whatever its origin, be seen through a vapour, that vapour prevents the passage of such components of the light as the vapour itself or the body from which it arises would emit if in a state of incandescence. Thus in the field of view dark bars or lines are produced, indicating the absence of some one or more of the components of the light. By the method of spectrum analysis, its authors discovered the two new metals, rubidium and cœsium; Mr. Crookes discovered a third new metal, thallium; the dark lines of Frauenhofer, in the solar spectrum, have been explained, and scientific investigators have been enabled to determine the nature of the prominences enveloping the sun during a total eclipse, and to extend their researches to solar, planetary, and even stellar chemistry.

Conservation or Correlation of Force.—In this connection it may not be out of place to refer briefly to the great generalisation of modern times, the law of the persistence,

conservation, or correlation of force. Newton, in the case of the impact of bodies, established the persistence of mechanical force; and Lavoisier, as already explained, showed that there was no destruction, but merely transformation, of matter in combustion and evaporation. The scientific researches of modern days have led to a great extension of the principle. Not only mechanical force, but other forces, such as heat, chemical attraction, electricity, nerve force, are shown to be persistent—can neither be created by man nor annihilated, and under given conditions are mutually convertible. If a cannon-ball strikes a rock, heat is evolved. Heat, as is familiarly known, produces mechanical force, chemical attraction generates heat, and electricity has been shown to be convertible into nerve force, and indeed all the other forces.

Before bringing to a close this sketch of the development and progress of skilled labour, we must ask, "*Was ist der langen Rede kürzer Sinn?*" or, "What is the sum and substance of the long discourse?"

We have seen how from the very earliest ages the demands for food, clothing, fuel, and shelter have induced men to labour in order to procure by the simplest arts the necessaries of life; and how, when abundance and leisure were secured, the arts which administer to man's intellectual and moral nature, and which are no less necessary to his happiness, were also called into existence.

We have observed that men, seeking to escape the drudgery of manual labour, have relegated toil to the captive and the slave, or else contrived to economise muscular exertion, either by utilising the natural forces with which they were familiar, or by inventing and applying some sort of machinery.

The former of these two plans of proceeding has, on the whole, been a source of degradation to all parties, and of

danger to every community that has fostered it. The latter on the contrary, has been eminently beneficial. A display of ingenuity commonly excites emulation in all who witness it, and the successful working of a locomotive or a power-loom has often improved a whole neighbourhood; hence the mental energy aroused has been turned to good account, individually and socially.

In the next place, it is clear that intelligence has ever proved itself superior to ignorance; and that all the manifestations of the former have reacted favourably upon industry. Thus, while we have found that labour was enslaved and degraded in the morning of the world, we have, nevertheless, seen that the idea of human rights gradually advanced, and that, after centuries of oppression and superstition, better days arrived. Further, we have witnessed how capital was created by labour and thrift; how craftsmen became enfranchised and instructed; how professional and public teachers arose; how the arts of paper-making and printing supervened; how truth was demanded as the standard of authority, while aforetime authority had set itself up for truth; how science was developed by experiment and induction; how it became allied to agriculture as well as to manufacture, and finally to legislation and government.

Such are some of the achievements and the lessons of the past. Yet there are those who take a desponding view of the course of history, and who gainsay the idea of progress. As the axis of the earth, they argue, is inclined to the plane of its orbit, and the light and heat of the sun oscillate between the poles, so vegetation is a round of renovation and decay, and its zones are a type of the cycles of humanity—ceaseless revolution, but no progression.

Such a doctrine seems repugnant to reason and opposed to nature's earliest and latest records. What says the testimony of the rocks? Our earth has indeed been in constant mutation, but ever adapting itself to the requirements of a higher order of beings. The elements have become more

tranquil, the atmosphere purer, the animal life on its surface and in its depths more complex in organisation. Flowerless plants existed before flowering plants; fishes, reptiles, and the mammalia followed each other, at successive epochs of creation; latest, though not least, man appeared, and has he not advanced? What have we not witnessed? And may not the progress of the past be regarded in the light of promise for the future?

The conditions of continual advance involve points of dispute and of grave debate. To two only we will allude. Firstly—"For the creation of wealth and general well-being," says Mr. Horace Mann, "intelligence is the grand condition. The number of improvers will increase, as the intellectual constituency increases. In former times, and in most parts of the world even at the present day, not one man in a multitude has ever had such a development of mind as made it possible for him to become a contributor to art or science. Let this development precede, and contributions, numberless and of inestimable value, will be sure to follow. . . . If among ten well-educated children the chance is that at least one of them will originate some new and useful process in the arts, or will discover some new scientific principle, or some new application of one, then among a hundred such well-educated children, there is a moral certainty that there will be more than ten such originators or discoverers of new utilities; for the action of the mind is like the action of fire: one billet of wood will hardly burn alone, though dry as suns and north-west winds can make it, and though placed in the range of a current of air; ten such billets will burn well together; but a hundred will create a heat fifty times as intense as ten—will make a current of air to fan their own flame, and consume even greenness itself."

In harmony with this view, great mental activity, combined with the gradual exchange of empiricism for the generalisations of science, is a gratifying feature of our own age. There is not only a greater number of interested workers,

and an immensely wider sphere of action and observation open to them now than ever before, but a disposition to seek for and apply the teachings of facts, to ascertain the principles involved in the operations of nature, and in the workings of human society. Physics and political and social economy are bringing into order the lessons of experience and the dictates of common sense.

Secondly—Material progress alone will not suffice. There is no security for its continuance without a moral foundation. "The trust and boast of our period," says the Rev. James Martineau, "is not in its individual energy and virtue, but in its schemes of social and political improvement; in things to be done *for* us rather than *by* us; in what we are to *get*, more than in what we are to *be*. . . . Now, two methods exist of aiming at human improvement—by adjusting circumstances without, and by addressing the affections within; by creating facilities of position, or by developing force of character; by mechanism or by mind. The one is institutional and systematic, operating on a large scale, reaching individuals circuitously and at last; the other is personal and moral, the influence of soul on soul, life creating life, beginning in the regeneration of the individual, and spreading thence over communities; the one, in short, reforming from the circumference to the centre, the other from the centre to the circumference. And, in comparing these, it is not difficult to show the superior triumphs of the latter, the method of Christ and of Christianity."

Finally—on taking leave of this subject, I cannot better supplement every statement and confirm every argument than by submitting the following extract from Sir Humphry Davy's "Consolations in Travel," as truthful and as applicable now as forty years ago:—

"The results of intellectual labour or of scientific genius are permanent, and incapable of being lost. Monarchs change their plans, governments their objects; a fleet or an army effect their purpose, and then pass away; but a piece

of steel touched by the magnet preserves its character for ever, and secures to man the dominion of the trackless ocean. A new period of society may send armies from the shores of the Baltic to those of the Euxine, and the empire of the followers of Mahomet may be broken in pieces by a Northern people, and the dominion of the Britons in Asia may share the fate of that of Tamerlane or of Zinghis-khan, but the steamboat which ascends the Delaware or the St. Lawrence will continue to be used, and will carry the civilisation of an improved people into the deserts of North America, and into the wilds of Canada."

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